Materials & Methods

Selection & use of

metals, nonmetallics, parts, finishes,

in product design & manufacture

UNIVERSITY
APR 8

March, 1957

Hot Work Steels for Aircraft

Why Specify Prepregs?

Vinyl Coatings for Metal Products

Investment "X" Castings

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Hot Forged Parts

M&M Manual

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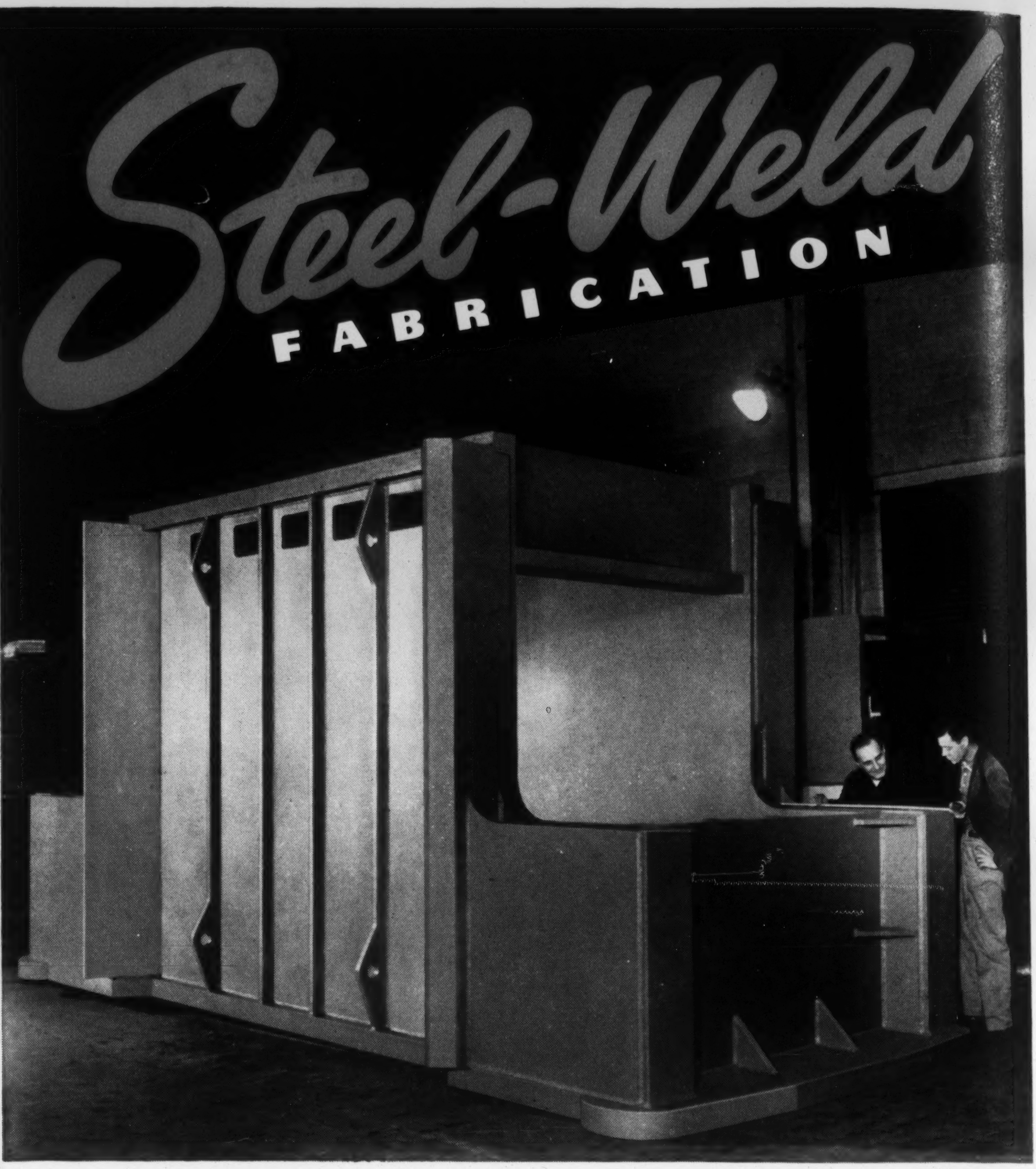
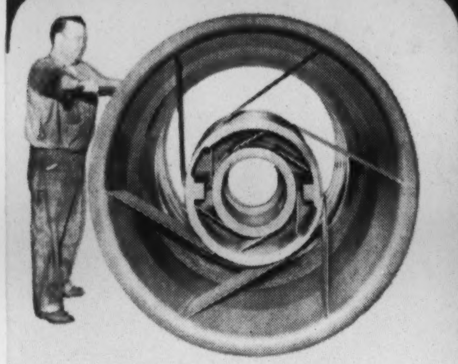
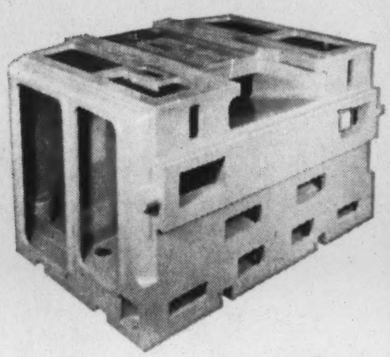
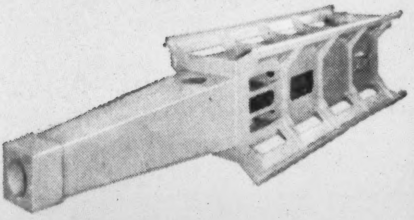
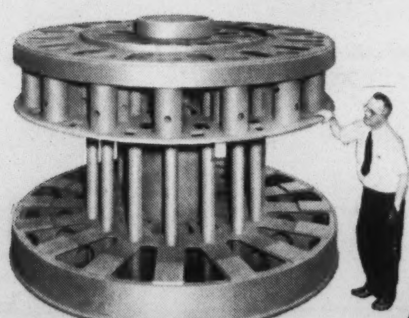


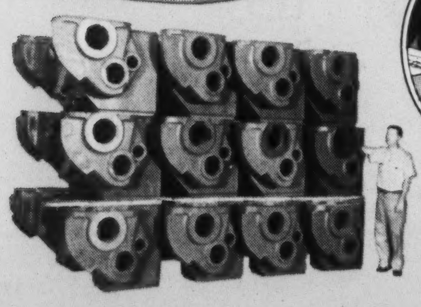
Steel-Weld FABRICATION

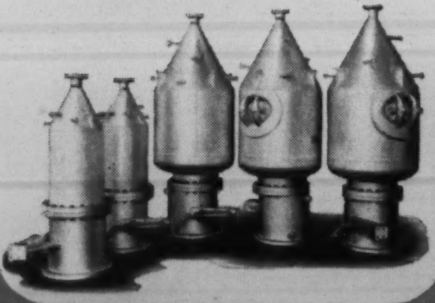


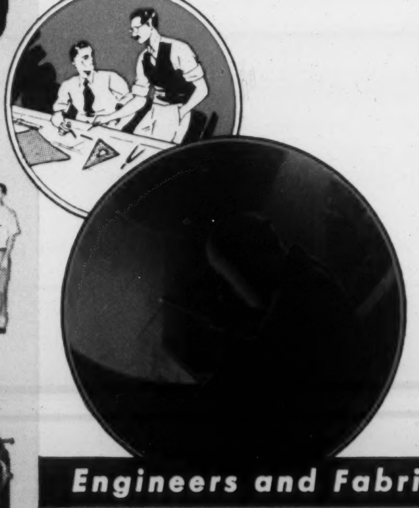












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Materials & Methods is indexed regularly in the Engineering Index and the Industrial Arts Index

Materials & Methods®

Selection & use of metals, nonmetallics, parts, finishes in product design & manufacture

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METAL QUIZ

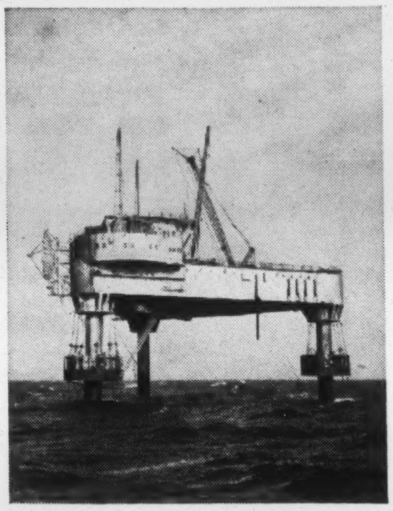
Each of these problems was solved successfully with an Inco Nickel Alloy
Can you tell which one proved to be the answer?

Number the picture captions!

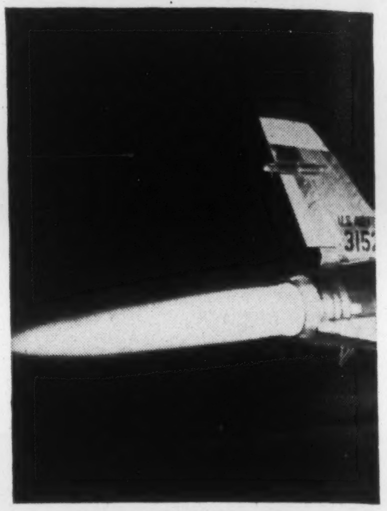
- 1 **"S" Monel** hard-grade nickel-copper cast alloy
- 2 **Inco Nickel**
- 3 **"K" Monel** age-hardenable nickel-copper alloy
- 4 **Inconel** nickel-chromium alloy
- 5 **Monel** nickel-copper alloy
- 6 **Inconel "X"** age-hardenable nickel-chromium alloy
- 7 **Monel "403"** non-magnetic nickel-copper alloy

See answers below

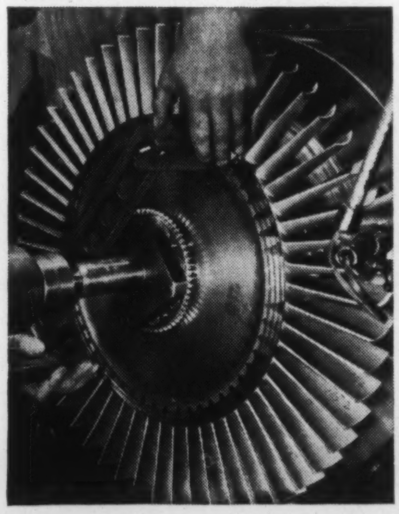
☐ **Oil well drill collar**—Needed: non-magnetic metal with high strength. Which Inco Nickel Alloy . . . ?



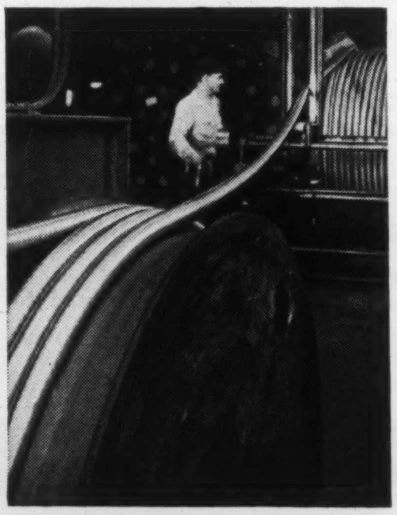
☐ **Radar platform "leggings"**—Needed: resistance to abrasion and marine corrosion. Which Inco Nickel Alloy . . . ?



☐ **Jet engine flame tube**—Needed: oxidation and corrosion resistance at jet engine temperatures. Which Inco Nickel Alloy . . . ?

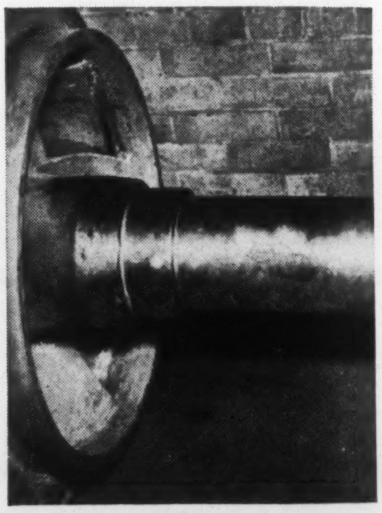


☐ **Gas turbine blades**—Needed: hot strength up to 1500°F., low coefficient of expansion. Which Inco Nickel Alloy . . . ?



☐ **Submarine cable sheathing**—Needed: non-magnetic metal resistant to marine corrosion. Which Inco Nickel Alloy . . . ?

☐ **Ultrasonic drill**—Needed: high magnetostrictive ability to produce ultrasonic vibrations. Which Inco Nickel Alloy . . . ?



☐ **Shaft sleeve for salt water pump**—Needed: extra-hard casting alloy that resists corrosion. Which one . . . ?

You may take this kind of quiz *again* . . . and soon! *Your* design may require a metal that resists corrosion . . . or wear . . . or high temperatures. Or one that meets some destructive *combination* of conditions.

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Oil well drill collar: 3. "K" Monel
Radar platform "leggings": 5. Monel
Jet engine flame tube: 4. Inconel
Gas turbine blades: 6. Inconel "X"
Submarine cable sheathing: 7. Monel "403"
Ultrasonic drill: 2. Inco Nickel
Pumps' shaft sleeve: 1. "S" Monel

For more information, turn to Reader Service Card, Circle No. 375

What's new IN MATERIALS

...AT A GLANCE

A BETTER TITANIUM SHEET ALLOY than presently available is the aim of a series of tests now being performed on an alloy containing vanadium as a major constituent. This new material is one of many being developed under the government titanium sheet program.

EVALUATING CRACKING TENDENCY OF A WELDED JOINT is possible with a new hot tensile testing machine. A welded sample is first melted, then allowed to solidify, after which a series of tensile tests are performed at temperatures descending from the metal's melting point. The usual method has been to test the welded sample at ascending temperatures.

LOW COST REINFORCED PLASTICS may result from an inexpensive bonded mat containing scrap natural and synthetic fibers, including wool. The bonded mat costs about 11¢ per lb, compared to 60¢ per lb for glass-reinforced mats. Such mats can reinforce polyester, phenolic, urea, vinyl and acrylic resins. Mechanical properties of such laminates, though somewhat lower than those of conventional laminates, are sufficient for many applications.

MAGNESIUM ANODES are being used on a 13,000-ton oil tanker to prevent rust and crust from forming on the vessel's metal hull. A 19-in. plastics-encased magnesium anode is bolted to the ship's hull to form a closed circuit between the metal hull and sea water.

A NEW MATERIAL THAT SCRATCHES DIAMOND has been developed. Cubic boron nitride is thought to be about as hard as a diamond, since each will scratch the other. It withstands temperatures of more than 3500 F, compared with a maximum of around 1600 F for diamonds. Still under development, the material appears promising for use in machining and grinding hard materials. (More details next month.)

CHEAP GRANULAR IRON is the aim of current experiments on direct reduction of iron ore. Direct reduction involves heating iron ores together with hydrogen or some other reducing gas to remove oxygen from the ore. Three processes are being studied; two use hydrogen as the reducing agent and the third uses a mixed gas derived from natural gas.

IMPROVED COLORFASTNESS OF NYLON is possible with a new process for dyeing filament nylon yarn. Nylon thus dyed can be safely washed at temperatures of 160 F — in some cases up to 212 F — whereas

120 F was previously considered the maximum for safe washing of colored nylon.

A FLUORINATED POLYESTER ELASTOMER has been developed as a fuel resistant rubber for applications in the temperature range of -65 to 300 F. This is one of the many elastomers being studied by the Air Force for use in air weapons; others include modified silicones, inorganic polymers and other fluoroelastomers.

HIGH PURITY IODIDE CHROMIUM is now available in experimental quantities. The new material, prepared by a process developed at Battelle Memorial Institute, is extremely ductile and corrosion resistant. (More details next month.)

A NEW HIGH STRENGTH, CAST STAINLESS ALLOY has high ductility even at a hardness of 300 Brinell, in addition to tensile strength of 140,000 psi and yield strength of 100,000 psi. The material has excellent corrosion resistance, including good resistance to hot oxidizing acid solutions. It also has good welding, machining and grinding characteristics. (More details next month.)

INJECTION MOLDING OF THERMOSETTING PLASTICS is now possible with a modified injection molding machine. The machine is designed to keep the temperature of the feed system at a minimum so that the molding material does not set up before injection.

INTRICATELY SHAPED PASSAGES IN CASTINGS are possible with a new sheathed-tube method of coring. Developed for aluminum and magnesium sand castings, the method uses a preformed metal tube sheathed in a flexible refractory sleeve. After molding, the tube is dissolved out by a chemical agent and the sleeve is removed, leaving a clean unlined passage.

EVALUATING MATERIALS AT TEMPERATURES UP TO 6000 F is possible with a new solar furnace. The basic component of the furnace is a 60-in. parabolic mirror which has a hard facing on its reflecting surface. Temperatures can be regulated to meet the needs of individual research programs.

GOLD PLATED GLASS WINDSHIELDS may be used to keep the sun's heat out of automobiles. The windshields, coated with a thin film of pure gold, reflect infrared rays and permit "cooler" wave lengths of light to pass through the glass.

TITANIUM SHUTTER BLADES no thicker than ordinary camera film will be used in cameras to achieve shutter speeds heretofore impossible. Titanium will be used because of its unique combination of strength, lightness and corrosion resistance.

MATERIALS BRIEFS

Tough Whiskers
A pure annealed iron whisker recently withstood a tensile stress of 1,900,000 psi before fracture. The whisker measured 0.000,000,004 sq in. in cross section and 0.1 in. in length.

Ducks That Dunk
Weather resistant butyrate plastic ducks bob their heads in and out of water just like real ducks. The life-like ducks are operated from a shooting blind on a 4½-v battery.

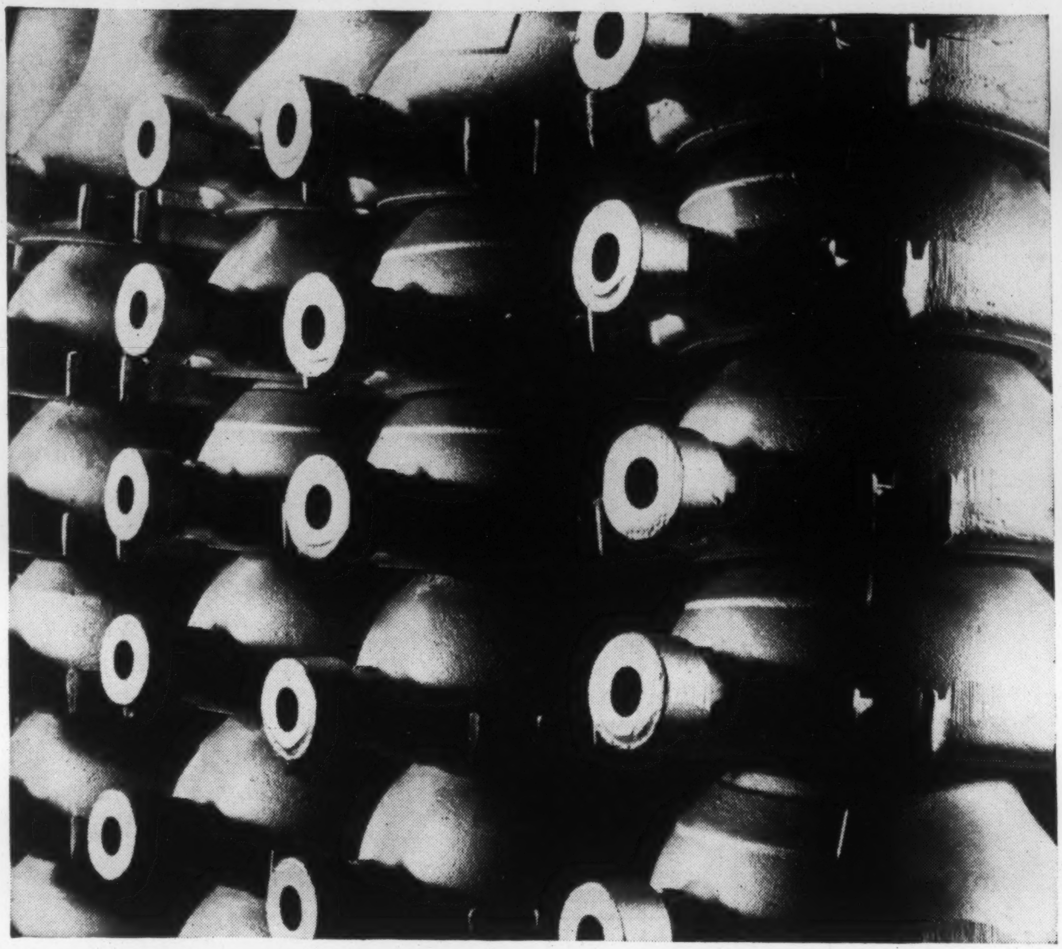
Old Scroll Revived
A copper Dead Sea Scroll believed to be 2000 years old was restored by coating it with a resin, then baking it in an oven. The hardened coating made the powdery copper scroll tough and permitted it to be cut open without falling apart.

Roses and Channel 5 Too
An aluminum device 32 in. wide and 72 in. tall can be used as a trellis and a television antenna at the same time. It can be covered with roses and vines with no interference to TV reception.

Bottoms Up?
A ski 5 ft wide and 16 ft long acts as a landing device on Navy patrol bombers in Antarctic service. Made of composite aluminum alloy and steel, the skis can be raised to permit landings on either wheels or skis.

Irish Blackboard
A green "blackboard" made of reinforced plastics does not squeal under chalk as traditional slate blackboards do.

Do you get the same performance from every lot of BRONZE you buy?



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- **Further Miniaturization**

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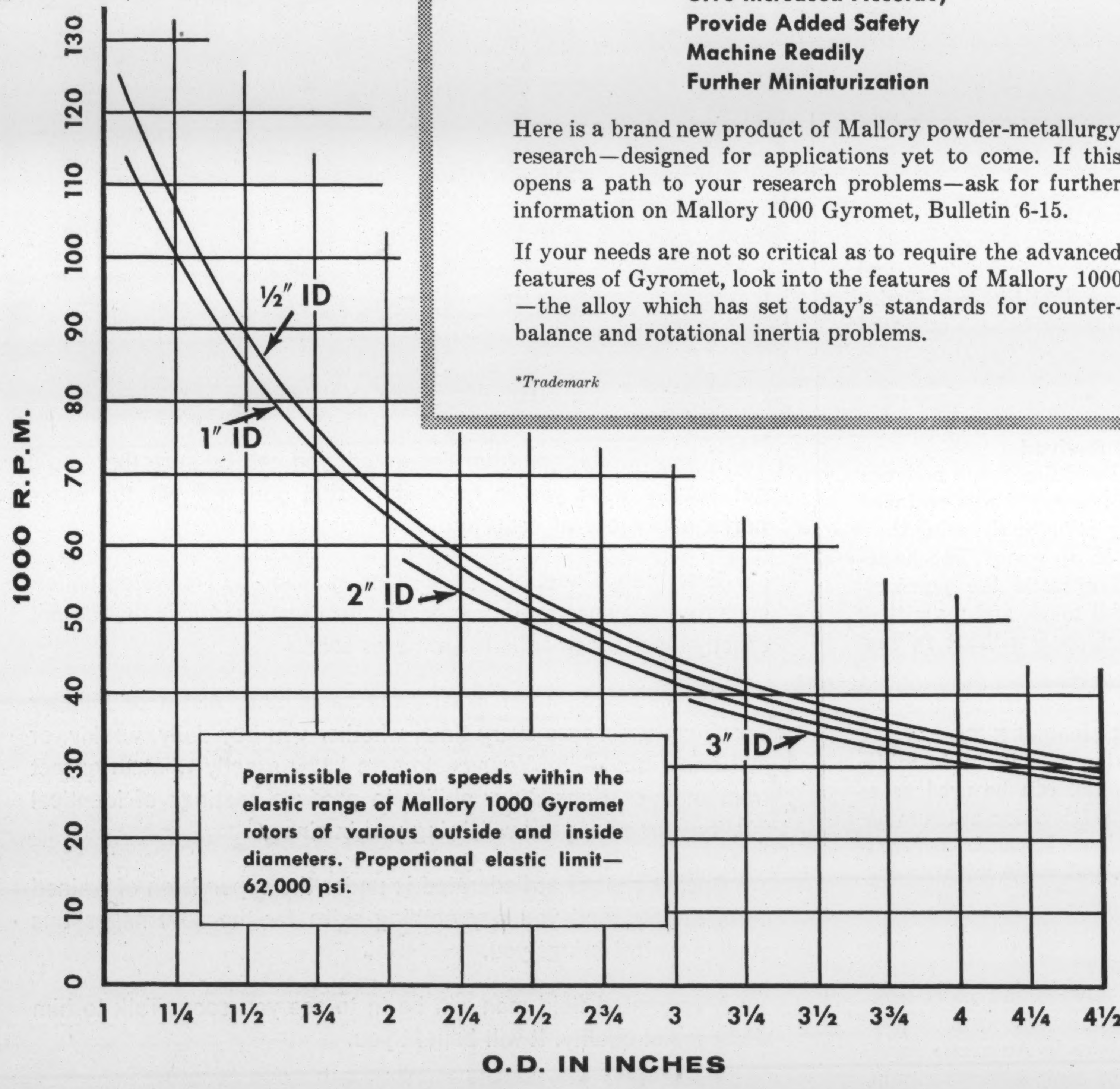

Permissible rotation speeds within the elastic range of Mallory 1000 Gyromet rotors of various outside and inside diameters. Proportional elastic limit—62,000 psi.

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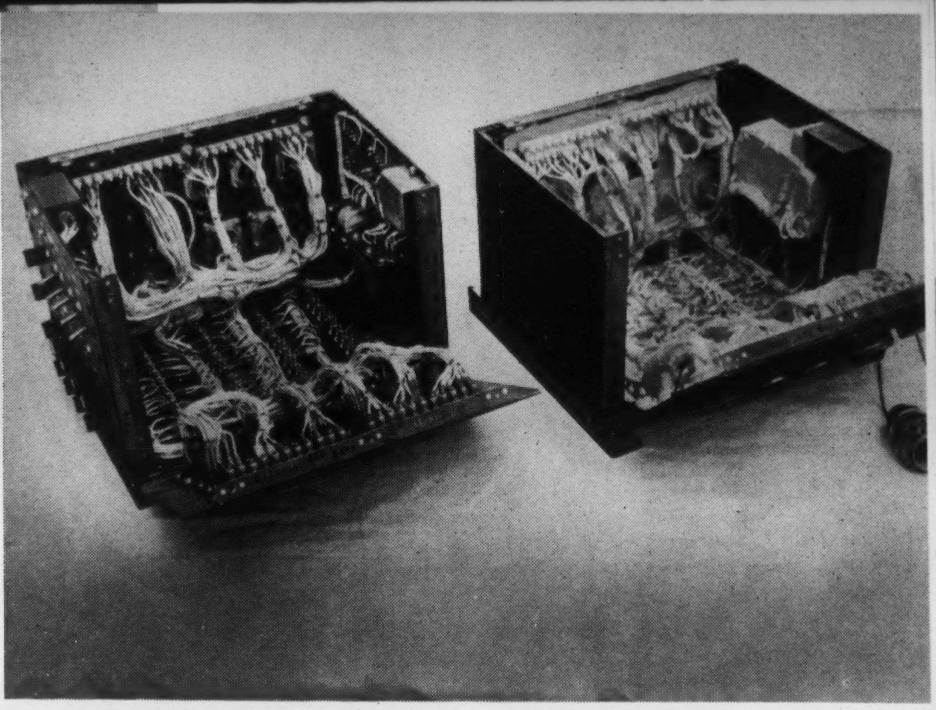
MATERIALS AT WORK

New and interesting applications of engineering materials

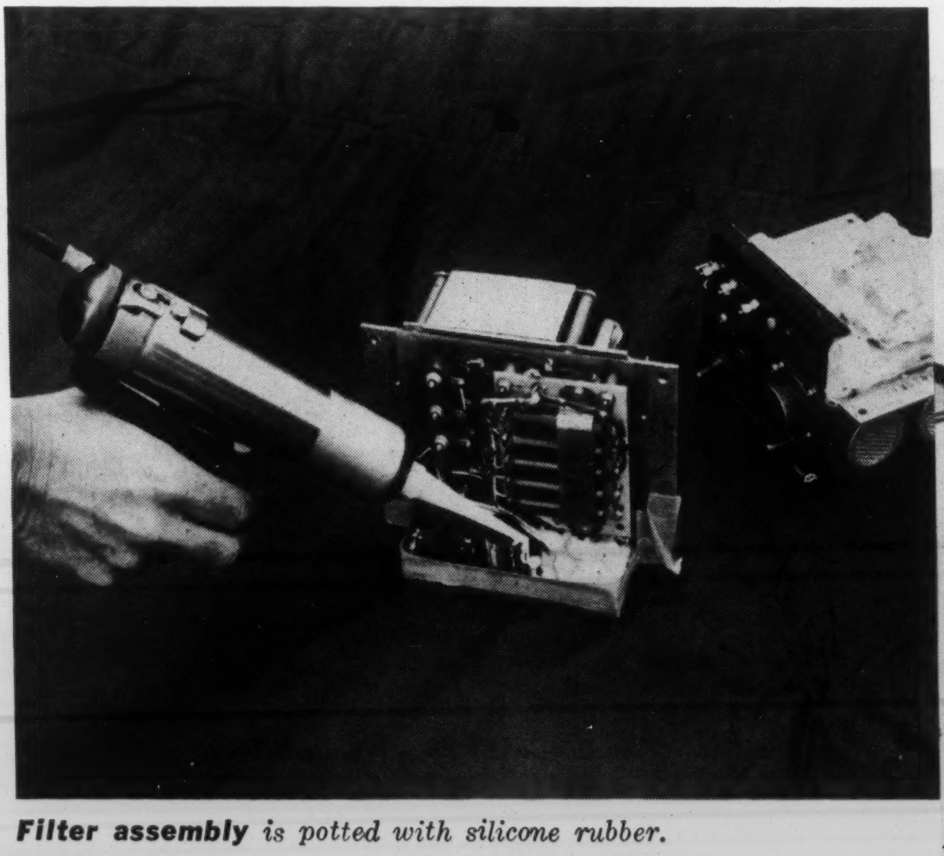


Fix junction boxes *before (left) and after (right) protective rubber coating is applied.*

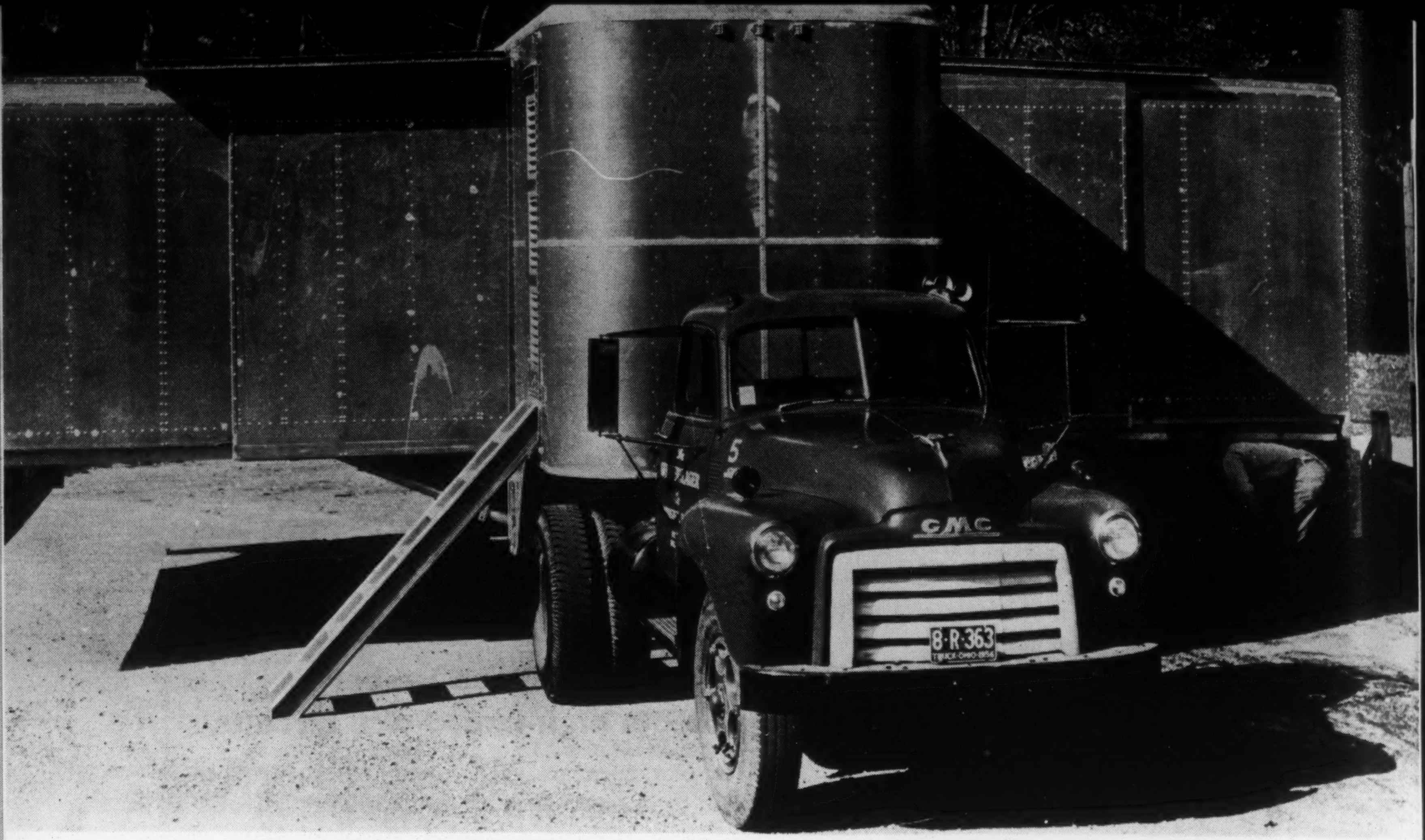
Sprayable silicone rubber protects high-impedance circuits

A new sprayable self-curing silicone rubber is used to protect vital high impedance circuits in Northrop Aircraft's guided missiles. After electronic panels in circuits are equipped with resistors, capacitors, transistors, etc., they are simply sprayed with rubber at about 100 psi air pressure. The material, supplied by Dow Corning Corp., cures rapidly at room temperature and is claimed to 1) cushion vibration at low temperature, 2) provide maximum moisture resistance, 3) improve electrical properties of the panel, especially surface resistivity, and 4) protect the assembly from rough handling.

An individual componet can be easily inspected by simply slitting the rubber coating and removing the unit. After the component is replaced, the slit is patched with the same material.



Filter assembly *is potted with silicone rubber.*

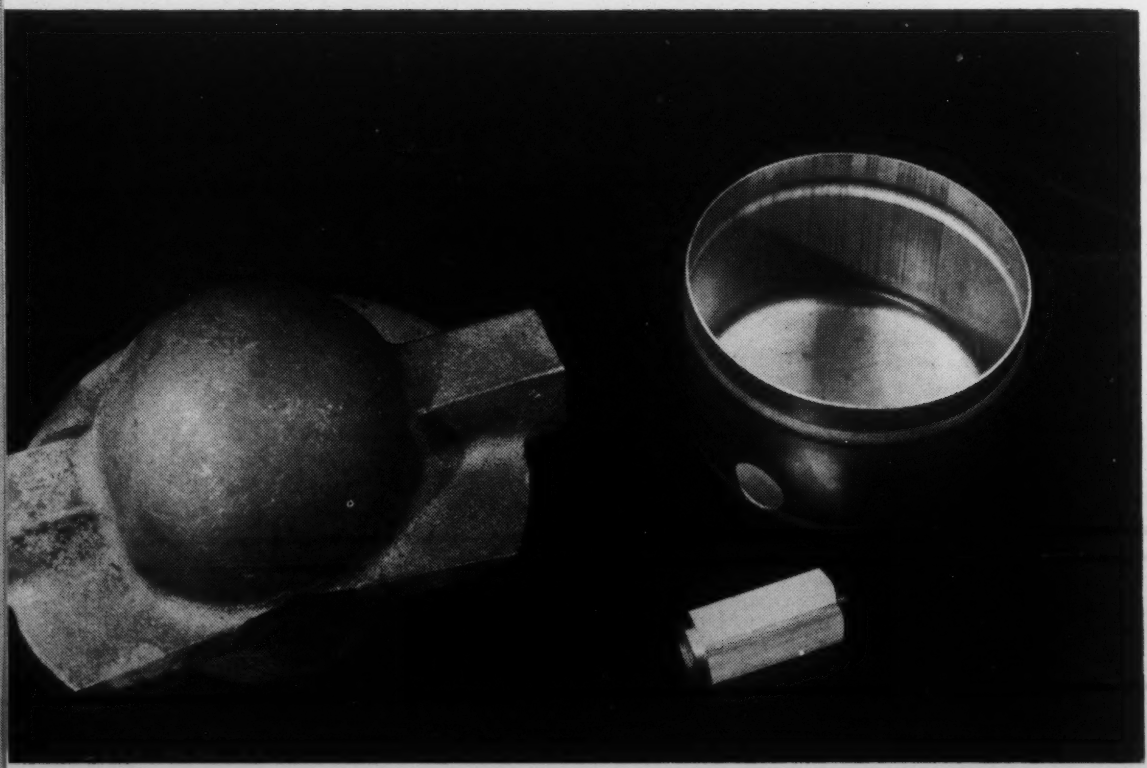


Aluminum Co. of America

Expandable aluminum truck

This strange looking vehicle is actually a conventional 14-ton aluminum truck which has been expanded to over five times its original dimensions. Powered by electrically operated hydraulic and chain drive mechanisms, sides of the trailer telescope outward, accordion-folded floors drop into place and, in a matter of minutes, floor dimensions change from 35 x 8 ft to 30 x 26 ft—from 150 to 780 sq ft.

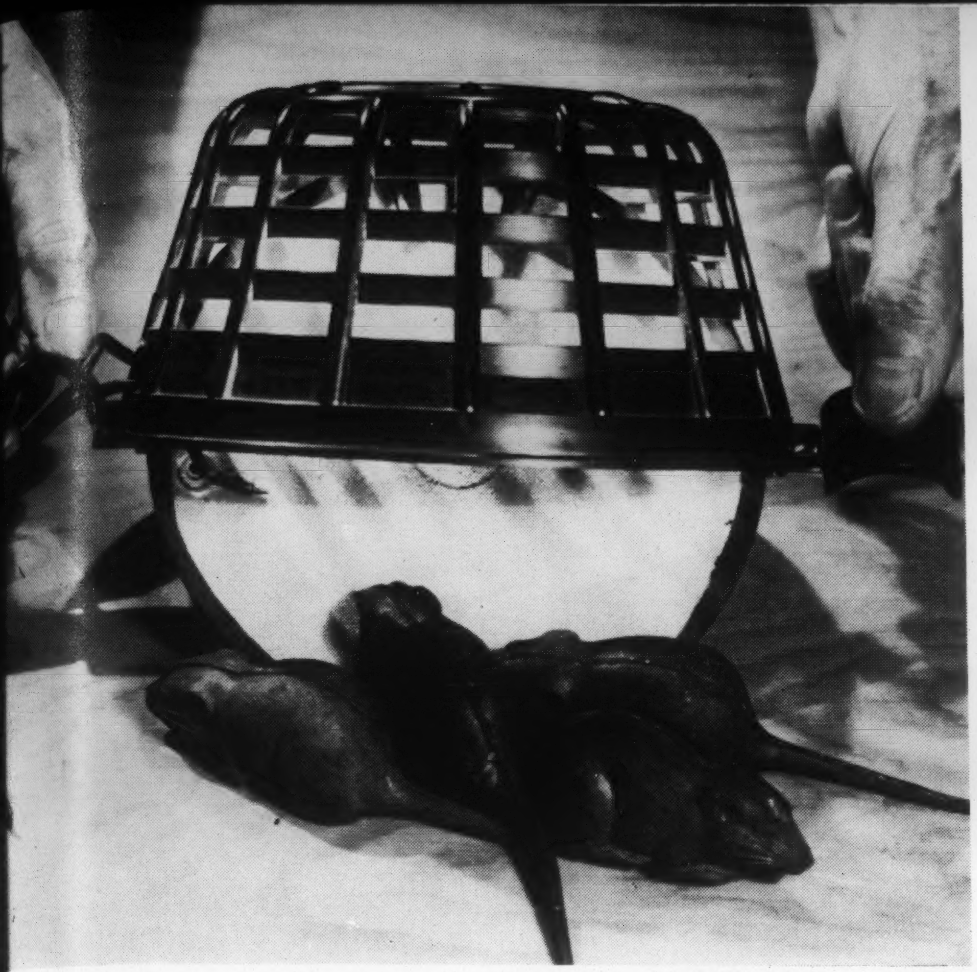
According to Gerstenslager Co., the manufacturer, this truck will find extensive use in the armed forces as a field hospital, kitchen, radar station, etc. Altogether, 12 tons of aluminum are used in the form of extrusions, sheet, plate and castings.



Armco Steel Corp.

Wrought stainless replaces cast iron

By switching from cast iron (left) to 304 stainless steel (right), Boston Machine Works Co. realized substantial reductions in both cost and weight on the vaporizer cups it manufactures for use in oil burners. The cost reduction was 35%—from \$1.36 to \$0.88, and the weight reduction was 90%—from 5 to ½ lb. The stainless steel cup is made by drawing and punching, welding on a machined stainless spud, and beading.



Catalin Corp. of America

Trap *is easily emptied by tipping open the pivoted floor. Mice shown here are vulcanized, not electrocuted.*

Mice get 'chair' of metallized plastic

Admiration Plastics Co. has come up with a better mousetrap. The trap is actually a "hot seat"—a cage consisting of a high impact polystyrene dome and floor, both coated on the inside with an electrically conductive zinc film. When the attached electrical cord is plugged into a circuit, the interior of the cage is connected to one pole, the floor to another. The unsuspecting mouse, searching for food, inevitably completes a circuit from floor to wall, thereby electrocuting himself. This bloodless purge of mice is claimed to be more efficient than the older, more brutal techniques.

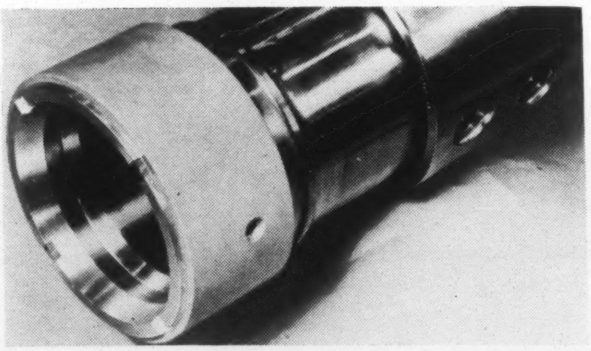
The metallizing process, of doubtful interest to the mouse, represents an improvement over previous techniques in which plastics tended to melt under the heat of the molten metal. Although details of the technique are not available, the company claims that through careful masking and temperature control, the molten zinc can be sprayed on without damaging the plastic.

Plastics-clad aluminum for three point landing

Reinforced plastics team up with aluminum to meet the need for a lightweight, high strength bearing surface on pistons which can withstand the severe service requirements of shock-absorbing struts in aircraft landing gear.

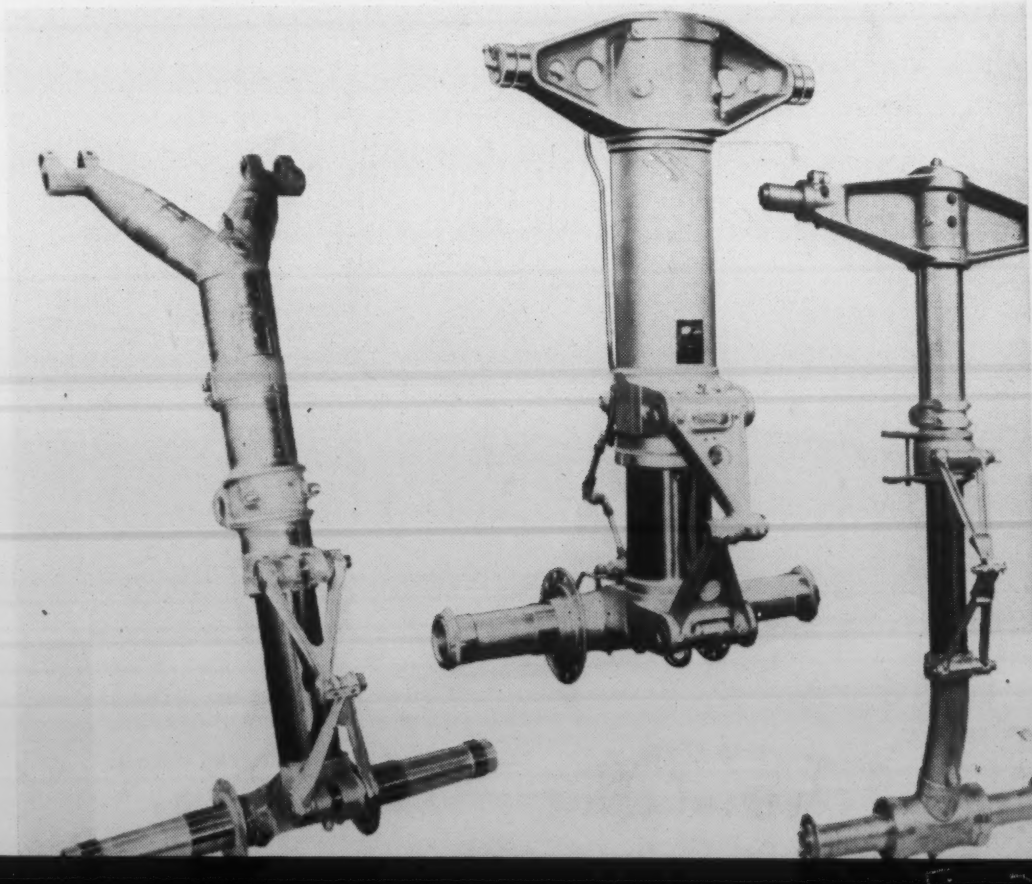
The pistons, which are aluminum cylinders with a layer of thermosetting reinforced plastics applied to the bearing surface, not only provide great strength at low weight, but eliminate corrosion, resist attack by lubricants or hydraulic fluids, resist scoring by dirt or dust particles, and eliminate metal-to-metal contact. In addition, considerably less maintenance is required.

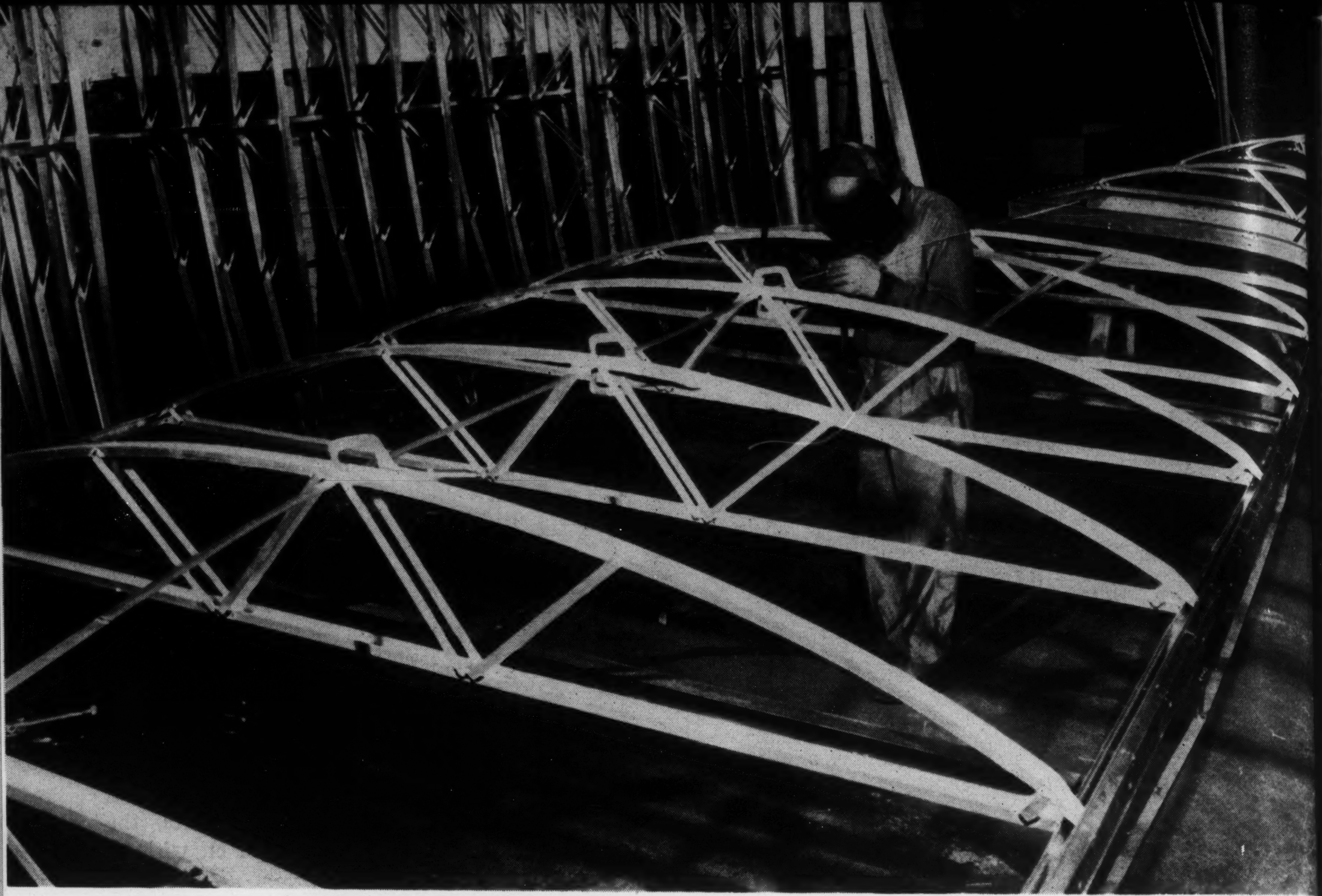
Designed by Cleveland Pneumatic Tool Co., the pistons are made by wrapping phenolic-impregnated cotton fabric around the knurled surface of a cylinder of 2024-T4 aluminum until the desired thickness is obtained. The fabric, supplied by Synthane Corp., is then polymerized under heat and pressure to produce a solid plastics sleeve securely bonded to the aluminum cylinder.



Close-up *of plastics-clad aluminum piston and bearing.*

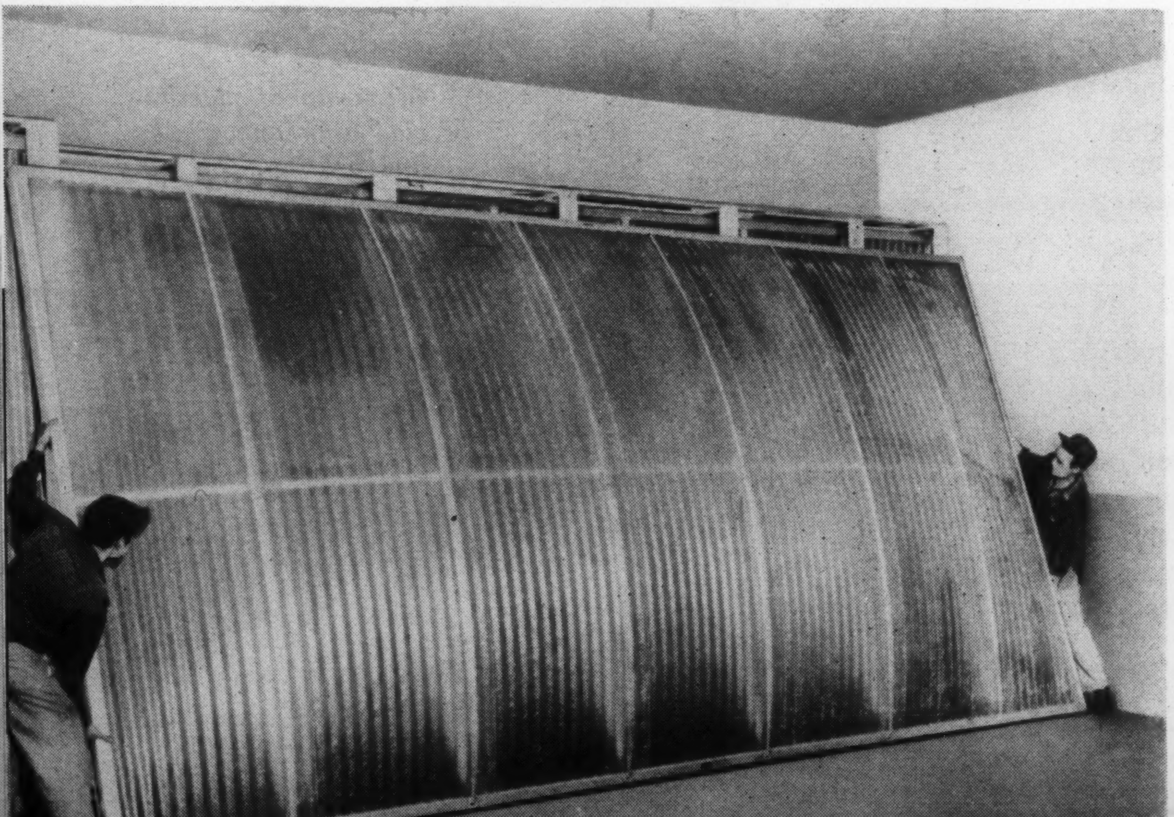
Landing gear *using the aluminum-plastics pistons include (left to right) Douglas C-124 main gear, Boeing B-50 main gear and Douglas C-124 nose gear.*





Lightweight structure *of aluminum and plastics . . .*

. . . makes skylight easy to transport and install.

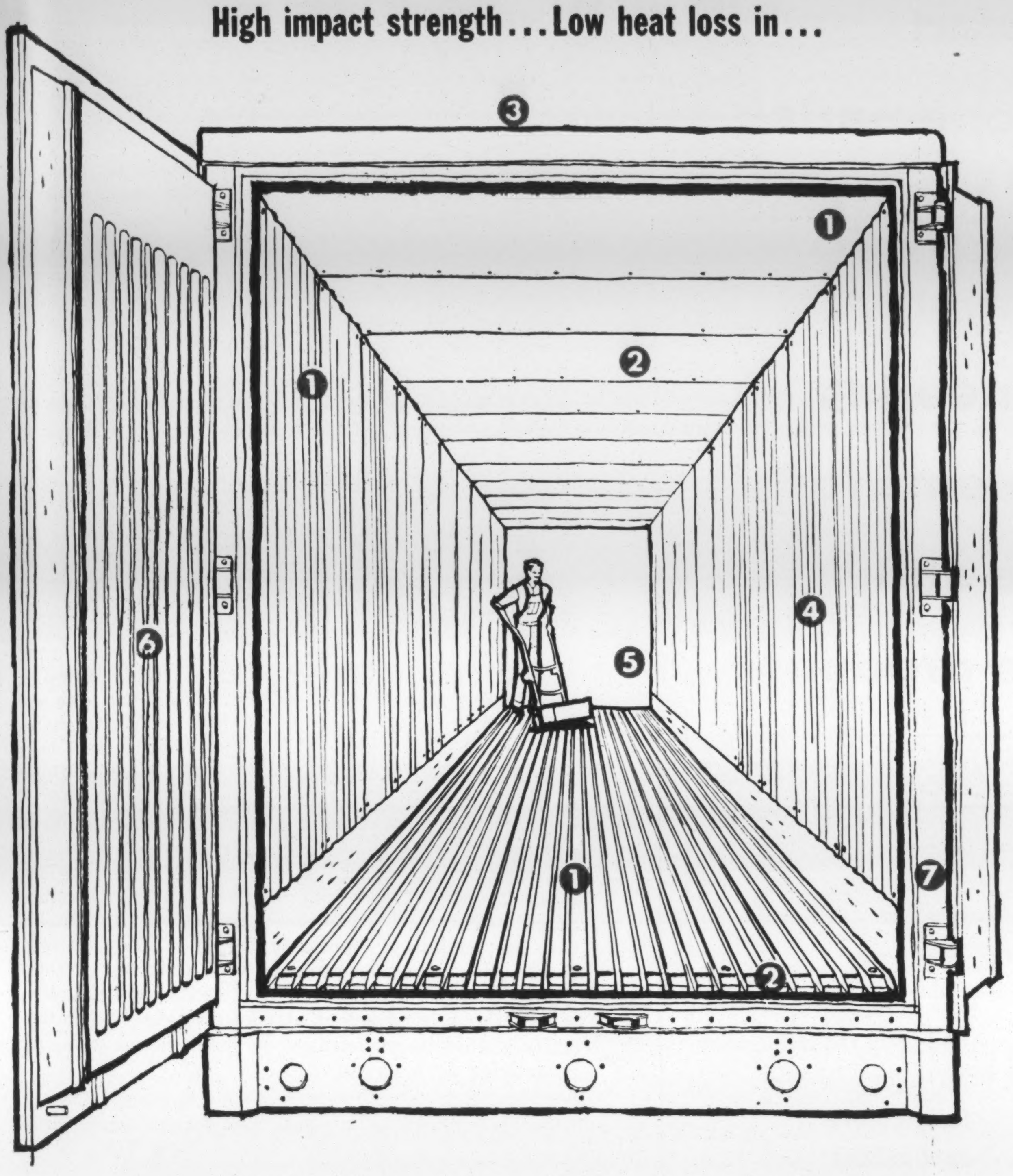


Metal + plastics = lightweight skylight

The skylight of metal and plastic shown here is claimed to be the largest of its kind. Manufactured by Marco Co., the skylight is prefabricated and preassembled into a unit which measures 9 x 20 ft, but weighs only 280 lb. The supporting frame is a wing-type structure consisting of extruded aluminum channel truss members heliarc welded to a perimeter frame. Fiberglass-reinforced polyester sheets, curved to a 12-ft radius, are placed over the frame and held with extruded aluminum retaining members.

The lightweight unit is easily hoisted to the roof, placed on prepared curbs and fastened with wood screws driven through prepunched holes.

High impact strength . . . Low heat loss in . . .



1. Posts, roof bows and floor channels made of Strick Lamicor® from glass-reinforced RCI POLYLITE polyester resin. Not a single case of fatigue failure in two years of over-the-road testing.
2. Ceiling lining and shear sheets made by Strick from POLYLITE and glass cloth or mat laminates up to 50" x 100".
3. Translucent skylights of very high impact strength Lamicor made of polyester resin with 45% glass reinforcement.
4. Corrugated side linings (with or without slotted edges) made of fibrous glass-reinforced POLYLITE. Strick offers these panels with either vertical or diagonal corrugation.
5. Lining panels made of Strick Lamiclad® from POLYLITE and plywood laminates have excellent impact and cleaning properties.
6. Strick all-plastic trailer doors 4" and 6" thick made of reinforced POLYLITE resin in sizes up to 44" x 106".
7. Door framing made by Strick of reinforced POLYLITE in shapes up to 110" long.

Trailer components made by STRICK PLASTICS from RCI POLYLITE RESINS

• For two important reasons the Strick Plastics Division of Fruehauf Trailer Company, Perkasie, Pa., makes a wide range of trailer components from RCI POLYLITE polyester resin.

First, the strength-weight ratio of these reinforced polyester parts is superior to both aluminum and steel.

Second, the K-factor of heat loss through these plastic components is a small fraction of that for aluminum or steel. This advantage is especially important in reefer construction.

In "reefers", plastic components also eliminate the danger of cargo spoilage from wood stringers that have become rotted, pest-infested or odor-contaminated. Plastic parts made with POLYLITE resin do not rot or attract pests. They are durable and easily cleaned.

At RCI we have three lightweight, plastic trailers that were made for us by Strick. Entire exterior, interior and all structural members of these insulated vans are made of reinforced RCI POLYLITE polyester resin.

In small parts or something as big as a whole trailer POLYLITE construction can offer *you* advantages, too. Do you want lightweight strength? Durability? Easy maintenance? Bright built-in colors or translucence? Write to RCI about POLYLITE for your products. Ask for *Booklet A.* Reichhold Chemicals, Inc., RCI Building, White Plains, N. Y.

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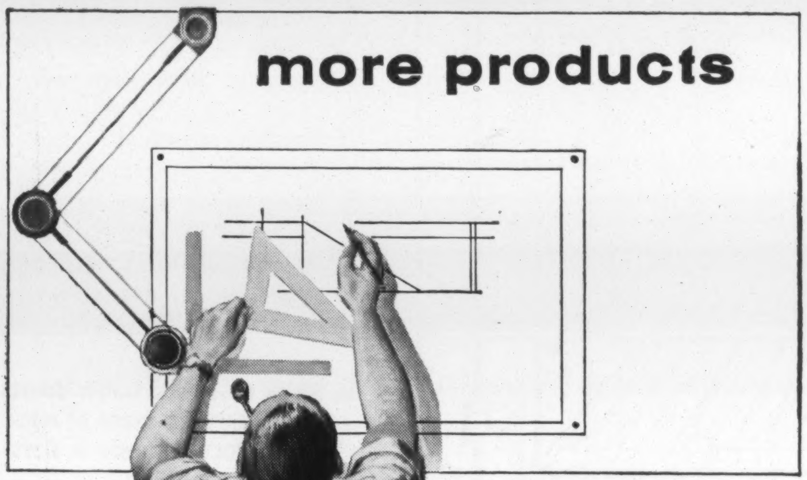
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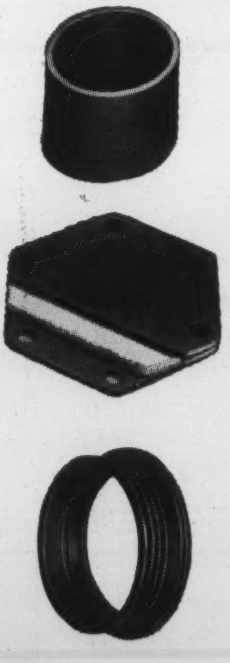

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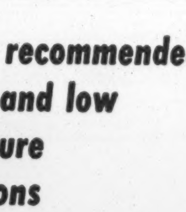

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M&M LETTERS
Letters
to the editor

Nickel silver alloys

To the Editor:

I have read with considerable interest your manual in the December issue of MATERIALS & METHODS entitled "Nickel Silvers." Such articles are extremely helpful to engineers concerned with materials problems. However, it is to be regretted that you did not see fit to include the 56.5-12 nickel silver alloy (ASTM B 122, Alloy No. 8) which was developed as a replacement for the higher nickel 55-18 alloy.

Our published data show that the 12% alloy can be and is used in place of the 18% alloy with consequent savings of strategic nickel—a highly important matter today. Similarly the 65-18 alloy (ASTM B 122, No. 2) can be replaced with an alloy containing only 10% nickel. Such reductions in nickel content without impairment of useful engineering properties should be encouraged by widespread publicity in articles such as yours.

GEORGE R. GOHN
Bell Telephone Laboratories
New York, N. Y.

There are at least 25 variations in composition in the nickel silvers; space limitations prevented discussing all of them. Although we are aware that the 56.5-12 alloy is included in the ASTM standards, it was not listed as a stock alloy by the producers who supplied information for the manual, nor is it included in the Copper & Brass Research Assn. Standards. However, we certainly agree that use of lower nickel alloys, where feasible, should be encouraged.

Engineering aides

To the Editor:

I was very much interested in the inquiry by Raymond Rosenberg regarding engineers' aides, and also in your reply (Nov '56, p 14).

Courses with a terminal objective of engineers' aide or technician have been conducted in New York State, and particularly in New York City, for a number of years. These courses are at high school and post high school levels.

Courses at high school level are conducted in vocational and technical high schools. They are four year courses. Students are selected on the basis of screening examinations and review of their school record. Some are classified as of above average intelligence. In addition to general education subjects, their training consists of four years of mathematics and four years of applied science and laboratory work, as well as some shopwork. Teachers of tech-

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Letters to the Editor

nical subjects are recruited from the various engineering fields.

Courses at the post high school level are conducted in the community colleges, formerly known as State Institutes. They are two year courses. Students are carefully selected; high school graduation is required. Teachers are recruited from the engineering field.

Industry's acceptance of these students has been somewhat spotty. We attribute it to the lack of a clear-cut definition on the part of industry as to what constitutes an engineering aide or technician.

Is an engineering aide or technician a person who brings to the engineer certain skills and knowledges that may be learned in high school, or in a post high school institute, or is he a skilled mechanic who brings his knowledge and skill to supplement that of the engineer, or is he a combination of both?

In any case, I believe that local education would be most willing to work with industry to meet industry's needs through either a vocational technical program at high school level or an evening extension program for the skilled craftsman.

WILLIAM D. KRAENGEL
Coordinator, Evening Trade Schools
New York, N. Y.

We certainly agree with the need for clear cut definitions of the abilities and functions of both the engineer's aide and the technician. We would like to hear more from our readers on this subject and to do all we can to develop closer liaison between industry and the schools.

On behalf of 'columbium'

To the Editor:

Congratulations to you for your excellent editorial on columbium vs "niobium" in the November issue of MATERIALS & METHODS.

I sincerely hope that the name columbium will continue to be used for element 41, for the reasons you gave and for many other good ones.

H. G. TANNER
Frederick, Md.

Luminous window frames

To the Editor:

I know that a window frame made with a plastics material that can emit light is manufactured in the United States.

Can you tell me the name of the manufacturer?

ADRIANO C. DUCATI
Newport Beach, Calif.

We do not know a window frame manufacturer who produces a plastics frame that will emit light. Luminous Resins, Inc., of Chicago, Ill. may be able to help. They produce phosphorescent polystyrene, polyethylene, polyvinyl chloride and acrylic molding materials.

ONE POINT OF VIEW

In May it will pay to attend the Design Show

May we suggest that you mark the week of May 20th on your calendar? It is the week of the second annual Design Engineering Show and Conference, and if you have anything to do with selecting materials and designing products we believe you will benefit by attending.

The show and conference this year will be held in the new Coliseum in New York City and all signs point to an even bigger and better affair than last year. There will be twice as many exhibits in the show, and the technical conference has been expanded to cover three times as many subjects.

The Show

Though double in size, the exposition will follow the successful pattern set last year. It will be devoted exclusively to the interests and problems of product planners, designers and engineering men in the original equipment and other hard goods manufacturing industries. Nearly half of the exhibits will display new as well as the older engineering materials, material forms and finishes. Technical specialists will be on hand to discuss with you specific problems and possible applications of their materials in your products. A wide range of mechanical, electrical, hydraulic and pneumatic components will also be exhibited. Clapp & Poliak, Inc., owner and manager of the show, expects that more than 300 companies will exhibit.

The Conference

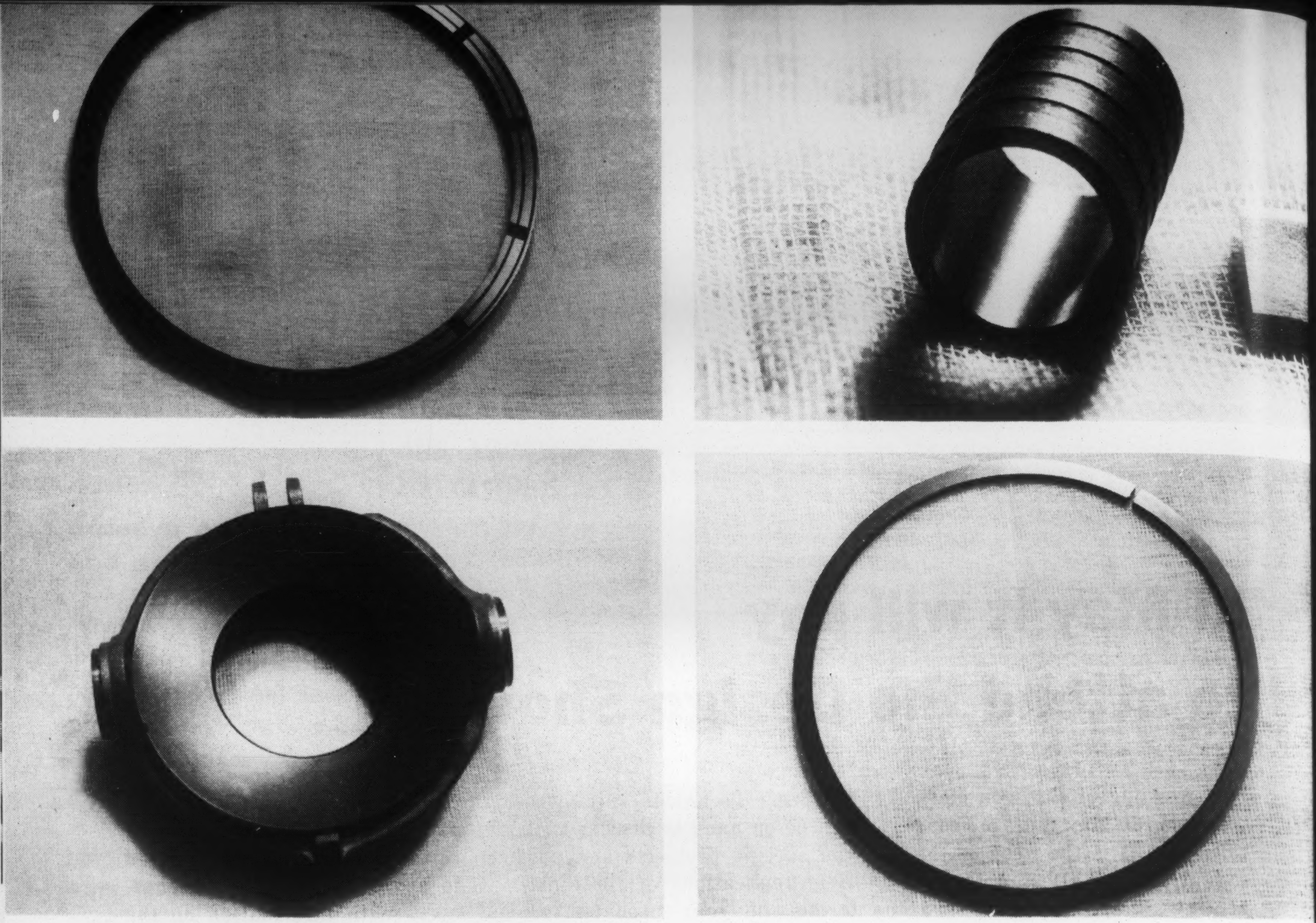
The Design Engineering Conference, to run May 20-22, will again be sponsored by the Machine Design Division of the American Society of Mechanical Engineers, the program being arranged by the editors of four leading publications in the design engineering field: MATERIALS & METHODS, *Product Engineering, Machine Design* and *Electrical Manufacturing.*

A panel session on the first day of the Conference will explore methods of developing profitable designs. On the other two days there will be three concurrent sessions covering a wide range of materials and design engineering subjects. Two of the sessions will be of particular interest to M&M readers, for they are planned to provide designers and engineers with information on the latest developments in engineering materials for product design. The papers will cover metals, plastics, rubber, ceramics and finishes.

Awards, too

Another important event will take place during the week of the Design Engineering Show. At a special dinner, the awards winners in the 1957 MATERIALS & METHODS Awards Competition for Best Use of Materials in Product Design will be honored. This event will conclude the first of what will be annual competitions — a program established to recognize outstanding applications of materials in the design of industrial and consumer products.

All in all the week of May 20th will be a busy one, and we hope you will be in New York to take part in the activities. We feel sure you will find it well worth your time.



Typical carbon shapes *used for bearings and seals are shown here.*

Carbon Bearings and Seals

by R. L. Hibbard, *Chief Engineer, Pure Carbon Co., Inc.*

Self-lubricating ability is one of the primary characteristics that makes carbons suited for use in bearings and seals. Other properties of carbons used in designing bearings and seals include conformability, compressibility, good compressive strength, absence of creep and a relatively broad elastic range resulting in a large compressive strain at the elastic limit.

The table on page 113 compares the properties of three grades of carbon with those of two metals and a ceramic. In a general comparison with other materials carbon has: 1) better conformability and a greater elastic limit than ceramics, 2) outstanding resistance to thermal shock, 3) an elastic limit in compression that is generally five to ten times greater than the elastic limit in tension, 4) a degree of strain at the elastic limit in tension about comparable to that of cast iron, 5) better machinability than ceramics, 6) truly elastic characteristics, i.e., it fractures at the elastic limit, and 7) compressibility, particularly important in press or shrink-fitted bearing sleeves since it permits the i.d. to remain constant under the external pressure of the metal housing.

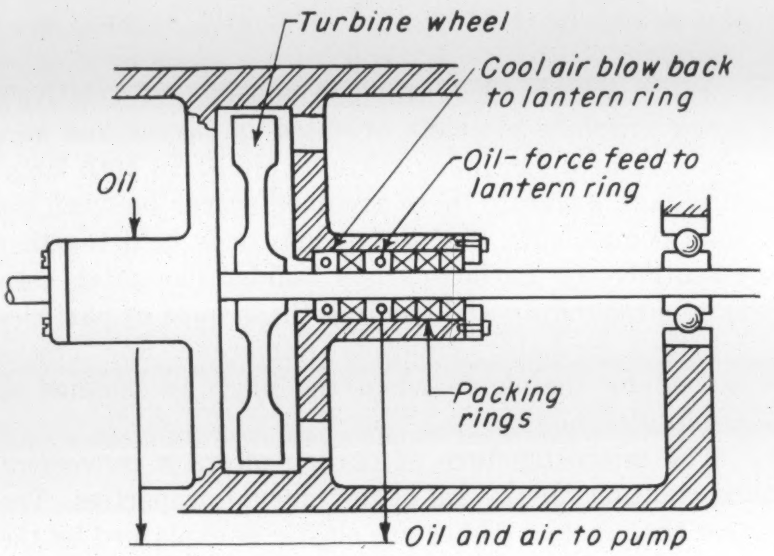
Specific properties of a mechanical carbon depend on the grade. There are many different grades of carbon, consisting of mixtures of various types of carbons and various types of graphite. Grades impregnated with resins, metals or various organic compounds are also available; the impregnants enable them to perform under unusual conditions of temperature, pressure, speed and environment. The proper grade of carbon to select is that one that will permit a self-regenerating, graphitic, interfacial layer to form at running surfaces under the particular service conditions encountered. After the proper grade has been selected, design must be such that frictional heat generation is balanced against heat removal rate to limit temperatures of running parts to the safe operating temperature of the particular grade and the metal parts used.

They can solve tough design problems

Today's technology requires an increasing number of bearings and mechanical seals that function where conventional lubrication is inconvenient, difficult or impossible. The following problems show how carbon can be used to simplify design where this lubrication problem exists. For each problem two possible design solutions are shown: one with and one without carbon.

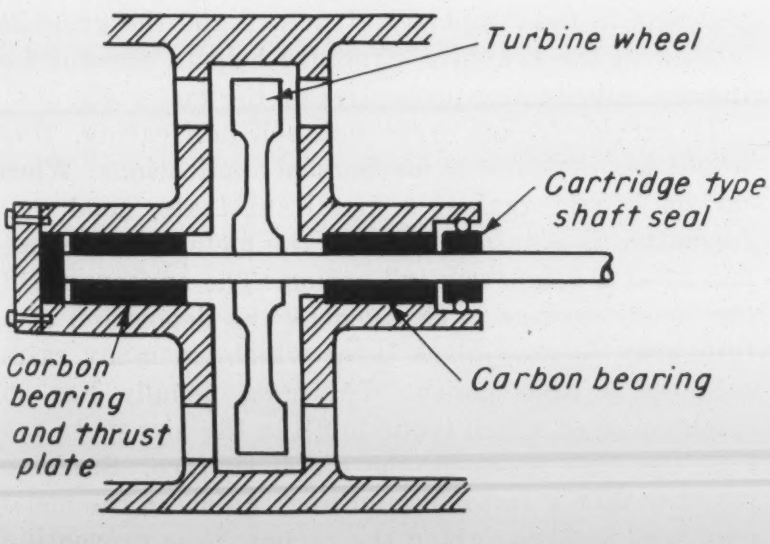
Problem 1—Air turbine

Design bearings and seals for an air turbine to be supplied with 600 F air which cannot be contaminated with oil.


Turbine wheel
Cool air blow back to lantern ring
Oil
Oil-force feed to lantern ring
Packing rings
Oil and air to pump

Solution without carbon — Massive packing gland is required, probably with cold air blow-back to keep gland from overheating and prevent packing gland lubricant from entering turbine case. A secondary lantern ring supplied with force feed oil lubrication would probably be required. Ball bearings mounted outboard of packing gland might be used.

Such a design is unwieldy, costly, heavy and subject to vibration problems due to long shaft overhang. It imposes additional requirements on the lubrication system, increasing weight and cost.

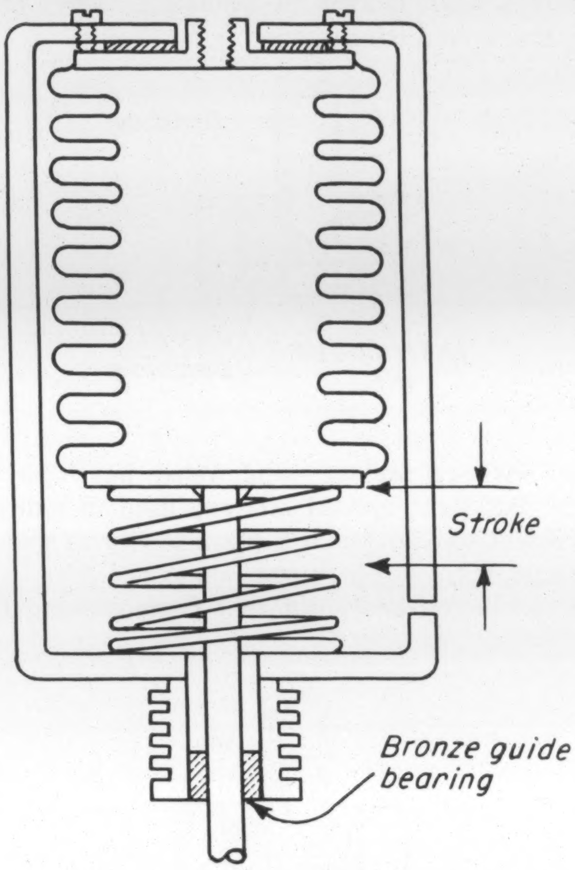

Turbine wheel
Cartridge type shaft seal
Carbon bearing and thrust plate
Carbon bearing

Solution with carbon — Select a high temperature resin-impregnated grade to form a carbon sleeve and thrust bearing, coupled with a mechanical seal.

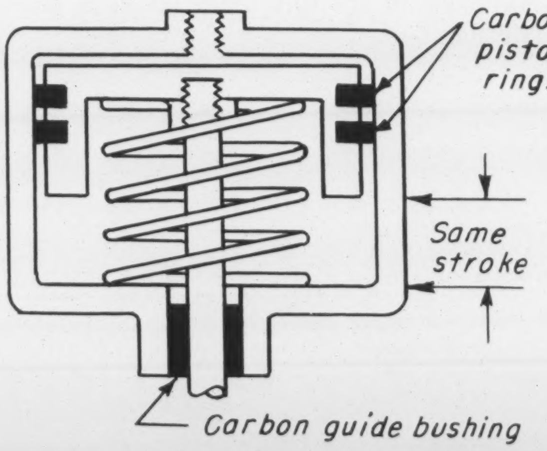
Entire structure is reduced in size, weight and cost and there is no possibility of oil contamination of the air.

Problem 2—Actuator

Design a pneumatically operated actuator which will be used with 1000 F air or some equally hot process gas.


Stroke
Bronze guide bearing

Solution without carbon — A stainless steel bellows with a cooled, external bronze guide bushing might be specified. Reliable lubricants have not been developed for use at this temperature range, so metal piston rings would be unsuitable because of galling; rubber, leather or plastics seals or boots would be destroyed.

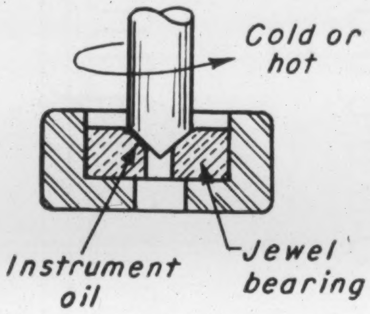

Carbon piston rings
Same stroke
Carbon guide bushing

Solution with carbon — Use a pair of carbon piston rings and a carbon guide bushing, made of a special composition which will perform successfully at 1000 F under the load and speed conditions encountered in an actuator. Differences in thermal expansion between the metal and the carbon can be accommodated by properly fabricating and prestressing both the piston rings and guide bushing so they will hug the housing. Proprietary carbon bushings of special design are available for this purpose. The prestress will be held in service or storage because of the lack of creep in carbon.

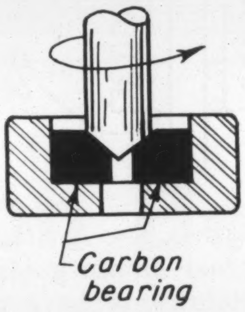
Such a design is much more compact and lower in cost than the design with no carbon.

Problem 3—Precision instrument

Design precision instrument pivot bearings that maintain a high degree of accuracy under changing temperature conditions.



Solution without carbon — Jeweled bearings provide long life, but light special oils are used in many cases. Such lubrication can make the sensitivity of the instrument vary with temperature changes. Also, starting friction can be markedly different from running friction.



Solution with carbon — A carbon bearing, mounted in substantially the same way as the jeweled bearing requires no lubricant. It greatly reduces changes in sensitivity that occur with temperature variations, as well as magnitude of the difference between starting and running friction.

Be sure you consider

Two distinct types of carbon bodies are widely used today: pitch coke-bonded lampblack and pitch coke-bonded graphite. A newer development is impregnated carbons, in which the carbon has been impregnated with resins, metals or various organic compounds to permit it to perform under unusual conditions.

Pitch coke-bonded lampblack consists of spherical particles of lampblack (10 to 100 millimicrons dia) bonded together by a continuous skin of coke. Each microsphere of lampblack is thought to consist of a random aggregation of hexagonal platelets resembling the polycyclic structure of aromatic organic compounds.

Pitch coke-bonded graphite consists of relatively large graphite platelets oriented in layers and surrounded by a continuous skin of pitch. In both lampblack and graphite there are open spaces between the solid components, and the structure is held together essentially by carbon-carbon bonds. The pitch coke skin surrounding and bonding the groups of particles together probably contains numerous fine cracks caused by shrinkage when the pitch is calcined to produce carbon.

The microstructure of carbon offers a convenient explanation for several of its unusual properties. The fact that carbon bodies are elastic is explained by the fact that the solid particles are held together by elastic carbon-carbon bonds. Carbon-carbon bonds are elastic in bending, which accounts for the fact that carbon bodies are deformable. The air spaces between the particles account for the fact that carbon bodies are compressible. The complete absence of a close-packed crystalline structure which can allow slippage between crystals, coupled with the elasticity of carbon-carbon bonds, explains the lack of creep. The high bond energy of carbon-carbon linkages also accounts for the exceptional refractory properties of carbon. And finally, the presence of tiny graphite-like platelets in the lampblack structure and the graphite lamina in the graphite structure help to account for the self-lubricating properties of the materials.

If carbon bodies were not self-lubricating, they would find little use in mechanical applications. When carbon is run against a metal substrate, good conformation is obtained between the metal and the carbon after a brief "run in" period. The appearance of the metal surface is changed by the deposition of a thin gray to gray-black layer which, in many cases achieves a high polish. This film usually has an oriented layer which tends to fill in the low spots and coat the high spots on the metal surface. Surfaces rougher than a 16 to 32-microinch finish on the metal may tend to file or grind the carbon, thus preventing deposition of the protective layer. The formation and continuous regeneration of this protective layer is an essential mechanism in the self-lubricating behavior of carbon bodies.

carbon's unique properties . . .

PROPERTIES OF CARBONS AND OTHER MATERIALS—A COMPARISON

	Carbon (soft graphitized)	Carbon (hard high coke)	Carbon (resin or metal-impregnated)	Cast Iron	Stainless Steel (best)	Super Refractories
Max Use Temp (in air), F	900	700	500–900	800 at 10,000 psi; 1100–no stress	1200 at 10,000 psi	3500
Max Use Temp (neut or red. atm),F	5000	5000[a]	600–1600	800 at 10,000 psi; 1100–no stress	1200 at 10,000 psi	3500
Ther cond, Btu/sq ft/hr/ft/°F	70–86	3–3.5	3–100	27	10.8	1.7–2.7
Coef of Ther Exp, per °F	1.50×10^{-6}	2.50×10^{-6}	$2.50–3.65 \times 10^{-6}$	5.9×10^{-6}	7.3×10^{-6}	4.3×10^{-6}
Ten Strain at Elast Limit, in./in.	0.0021	0.0016	0.0006–0.0018	0.0013–0.0029	0.0031–0.0033	0.0061
Compr Strain at Elast Limit, in./in.	0.0168	0.0165	0.0084–0.0260	0.0059–0.0071	0.0031–0.0033	0.0061
Elastic Modulus, 1000 psi	620	1430	1700–3223	13–21,000	27,600	52,300
Tensile Strength, psi	1300	2300	2000–3100	18–60,000	85–95,000	35,000 at r.t.; 18,500 at 2000 F
Compressive Strength, psi	10,400	23,600	27–50,000	80–150,000	85–95,000	320,000
Res to Thermal Shock	Ex.	Ex.	Ex.	Fair	Ex.	Poor

[a] Will graphitize.

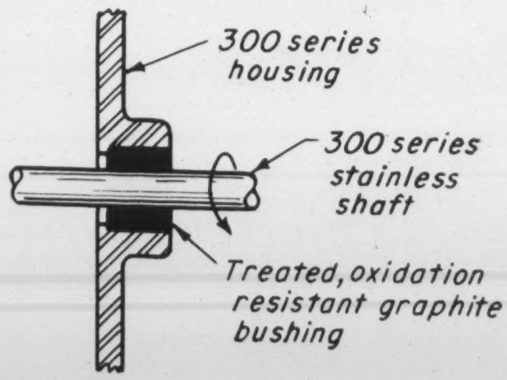
In impregnated graphite bodies, presence of the impregnants enhances the formation of the self-lubricating protective layer, though the mechanism is not well understood in all cases. Improvement is particularly noticeable when the carbon is running dry at temperatures over 200 F or in atmospheres deficient in water vapor and oxygen. Metals, resins and insoluble halide salts all have been found to prolong the life of carbon operating under such conditions.

. . . and design correctly

In many cases, though carbon parts can meet the specific design requirements, improper design may nullify the advantages of using the material. The designer or engineer should remember that carbon is not always size-for-size interchangeable with other types of bearings and seals. The following designs show poor and good use of carbon bearings and seals, and illustrate important applications of the material.

Case 1—Dry high temperature bearings

Speed: 2000 sfm
Load: 30 psi
Temperature: 1000 F (air)


300 series housing
300 series stainless shaft
Treated, oxidation resistant graphite bushing

Poor—1. Press fit is used. There is not enough initial interference to take care of the difference in thermal expansion between carbon and type 300 stainless steel. Over this temperature range, interference required would be over 0.007 in. per in. dia—too much interference for a press fit.

2. Initial clearance between carbon and shaft is only 0.0005 in. on a ½-in. dia shaft. As temperature of assembly approaches 1000 F, shaft expands enough to bind on bushing i.d., while housing i.d. expands away from bushing o.d.

Result—Carbon bushing turns with shaft, generating enough heat due to poor fits, poor finishes and binding forces to damage the metal and even oxidize the carbon.

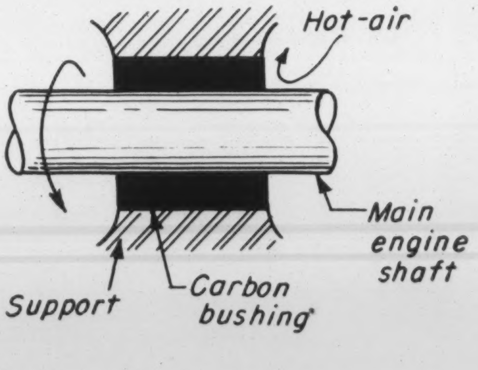
Good—1. Utilizing carbon's large permissible compressive strain and resistance to creep, bushing is shrink-fitted into housing with sufficient compressive prestress (due to interference) that bushing does not loosen even at 1000 F. As assembly heats up, housing and bushing expand at same rate, permitting bushing i.d. to increase at about same rate as shaft o.d.

2. Initial clearance between shaft and carbon bushing is made large enough (about 0.0015 in.) so that thermal lag between shaft heating and heating of bearing-housing assembly does not result in shaft expansion overtaking expansion of the bore of the bushing.

Result—Successful operation.

Case 2—Jet engine main shaft bearings

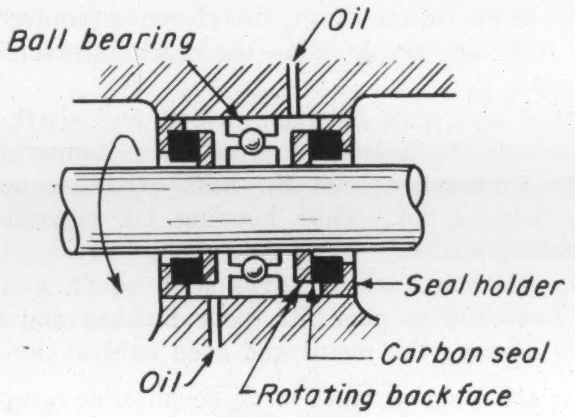
Speed: 8000 sfm



Poor—1. Only a few grades of carbon will maintain low wear and prevent excessive heat build-up operating at surface speeds of 8000 sfm and above. These grades operate best at loads below 20 psi—more often in the 10 psi range. To provide such low loading, shaft bearing must be quite long. Relatively little radial play is permissible on this type of shaft; hence, fit between carbon bushing and shaft might be on the order of 0.002 in. clearance. With such small clearance over length of long bearing, any bending or misalignment of the shaft could be disastrous. Also, such a small clearance would dictate use of a thin, flimsy bearing to insure rapid heat conduction to housing.

2. Even though coefficient of friction between shaft and carbon bushing may be only 0.10 to 0.05, such a bearing would be expected to absorb about 15 hp. To avoid overheating, a great deal of oil would have to be pumped through bearing. Consequently, seals would have to be installed at either end of bearing, further increasing length of assembly.

Result—Oversize, inefficient assembly.

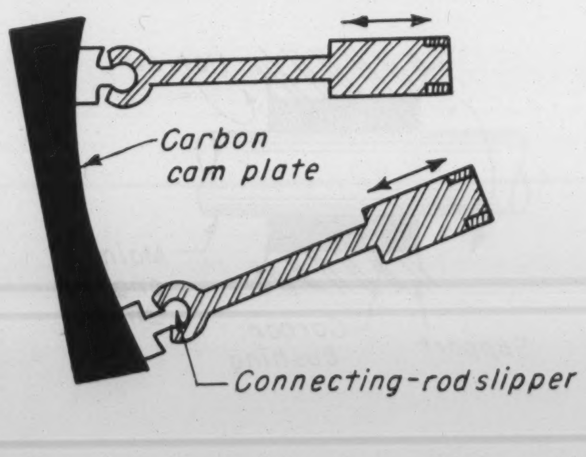


Good—Usual ball bearing, mechanical seal assembly handles speed-load requirements with normal amount of cooling and lubrication. Carbon seals, pressure-balanced for light face loads, separate bearing from engine gases.

Result—Compact assembly and economical operation.

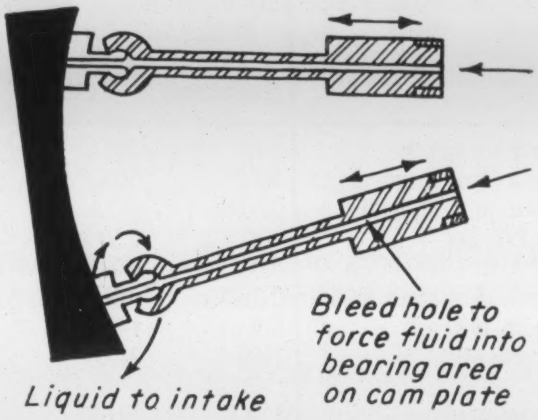
Case 3—Wobble Plate for Rotary Piston Pump

Speed: 2500 sfm
Load: 500-1000 psi



Poor—There is no provision for cooling contact area between carbon cam plate and metal wear shoes. Temperatures attained would be high enough to soften and destroy metal surface.

Result—Inoperative.



Good—Small port through the center of the piston carries fluid pumped to surface of wear shoe. As pressure of fluid is increased on the pressure stroke, load between wear shoe and cam plate also increases. Simultaneously, flow of coolant is increased by the increased fluid pressure.

Result—Relatively low cost, long life assembly.

Do's and Don'ts of Carbon Design

Do

1. Mount carbon in compression. In general, carbons have about five to ten times the strength and compressibility in compression that they do in tension.
2. Calculate the effect that thermal expansion will have and allow for it in your design.
3. Make sure that stresses in the mounting systems are within the working limits of all materials, including the carbon.
4. Estimate the amount of heat that will be generated, using known loads and speeds and a conservative coefficient of friction, such as 0.15 or 0.20, to see whether or not you need cooling.
5. Consult the carbon manufacturer for his recommendations on the proper grade or grades for your application, and obtain from him any data that you may need for design purposes.

Don't

1. Try to interchange carbon bushings with other types of bushings or bearings without full consideration of the factors involved.
2. Run rough shafts or thrust washers against carbon. Best success is obtained with finishes better than 10 rms.
3. Design a large carbon thrust bearing for operation under severe speed load conditions which require cooling without insuring a positive flow of coolant over the running surfaces. Relatively large bearing pad areas not containing numerous small oil grooves may overheat.

PROPRIETARY GRADE	STEEL	C	Mn	Si	Cr	Mo	W	V
Halcomb 218	A	0.38	0.34	1.10	5.21	1.38	—	0.40
Peerless J	D	0.54	0.30	0.39	1.36	1.59	2.77	1.35
Halmo	E	0.35	0.28	0.72	5.16	5.14	—	0.66

A further report

Hot Work Steels for Aircraft Structures

by Edward A. Loria, *Staff Metallurgist, Crucible Steel Co. of America*

■ The advantage of hot work steels over conventional high strength steels for aircraft structures lies in their resistance to softening at elevated temperatures. The resulting structural stability overcomes the aerodynamic and engine heating effects occurring in high speed flight. Advantages of hot work steels for such applications have been discussed in a previous article (M&M, Aug '55, p 94).

Two compositions, steel A and steel D, were discussed previously, but this article presents new data on properties at temperatures up to 1000 F. Steel E is included because of its combination of high rupture ductility and creep rupture strength.

Most aircraft parts are designed on a peak load basis; therefore short time tensile properties at room and at elevated temperatures are investigated first. However, it is now becoming important to evaluate structural stability, i. e., the effect of holding time at elevated temperatures on loss of strength at room temperatures. A number of specific applications also require knowledge of long time strength.

They look promising because of their 1. Short time properties

Fig 1 gives the elevated temperture tensile and yield strengths of steel A bars obtained at 100 F intervals up to 1200 F. Fig 2 gives the same information for A sheet. The data are shown for sheet and bar tempered to two different room temperature strength levels. Variation in bar size from 1 to 4 in. had little effect on the strength of bars heat treated to the 200,000 psi level. The curves in Fig 2 represent both longitudinal and tranverse properties of 0.040-in. thick sheet. They illustrate the trend observed for sheet ranging from 0.032 to 0.102 in. thick heat treated to the

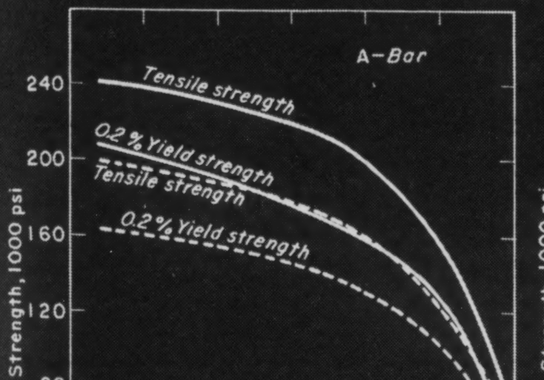


Fig 1 — Tensile and yield strengths of steel A bars.

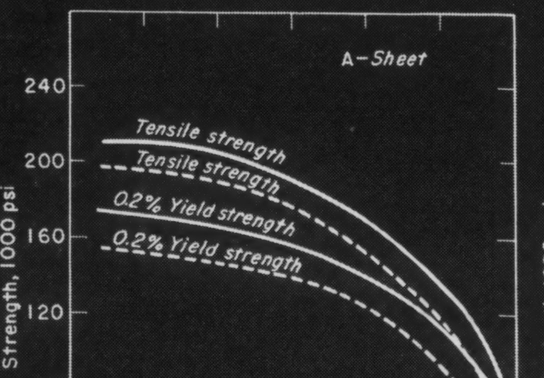


Fig 2—Tensile, yield strengths of steel A sheet (0.040 in.).

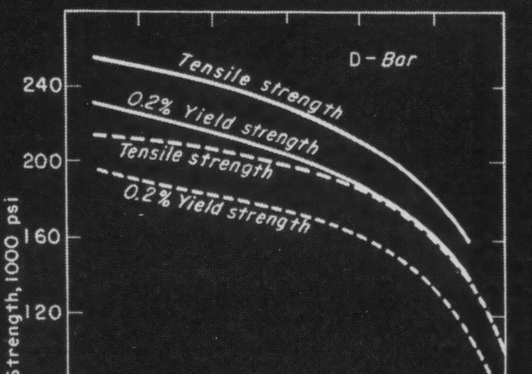


Fig 3 — Tensile and yield strengths of steel D bars.

International Nickel Co.

Supersonic aircraft *require materials that can withstand the extremely high temperatures resulting from aerodynamic heating. Plane shown here is Bell Aircraft's experimental X-2.*

TABLE 1—ELEVATED TEMPERATURE TENSILE PROPERTIES OF STEEL E BARS[a, b]

Temperature, F	Tensile Strength, psi	Yield Strength (0.2% offset) psi	Elongation, %	Reduction in Area, %
80	264,000	224,000	10	31
600	233,000	193,000	10	33
800	223,000	181,000	10	36
1000	199,000	165,000	10	32

[a] Bars austenitized at 1950 F for ½ hr, air cooled and tempered at 1050 F for 2 + 2 hr to Rc 51.

[b] Composition: 0.32 C, 0.32 Mn, 0.59 Si, 5.27 Cr, 5.13 Mo, 0.73% V.

200,000 psi tensile level.

Fig 3 shows the average elevated tensile properties of steel D bars heat treated at the 200-230,000 and 230-260,000 psi strength levels. It was shown in the previous article that this steel, when tempered at 1050 to 1300 F, has the highest resistance to softening of the steels discussed, and this observation appears to correlate with elevated temperature tensile strength. Steel D heat treated to the 250,000 psi level maintains its strength to the same degree as steel A heat treated to 240,000 psi. At and above 1000 F, it is distinctly superior to steel A in tensile and yield strengths. Between 1000 F and 1200 F, D provides tensile and yield strengths roughly 5-12,000 psi higher than those of A; in effect, steel D extends the design limit for these steels to 1100 F.

Like the other steels, steel E can be tempered to various strength levels. Oil quenching bars and forgings from 1950 F and double tempering at 1050 or 1100 F for 2 + 2 hr has produced Rc 52 hardness together with good tensile and creep rupture elongation. Table 1 gives room and elevated temperature tensile properties for the 1050 F temper. Retention of strength up to 1000 F is excellent.

2. High temperature stability

Room temperature tests show how well these alloys maintain their strength after various lengths of exposure to elevated temperatures. Table 2 gives room temperature data for steel A forgings (bar specimens) exposed to 1000 F, probably the maximum service temperature for this steel. Tensile properties of steel A hold up beyond 10 hr, but deteriorate after 100 hr continuous exposure. Table 3 gives similar data for steel D exposed to 1100 F, probably the peak service temperature for this steel. Steel D nearly maintains its room temperature tensile properties after 100 hr exposure at 1100 F.

Thus, structural stability tests confirm the earlier observation, based on short time tests, that steel D's service temperature range extends 100 F beyond that of steel A. Because of its higher carbon content, D has lower tensile ductility than A.

Tensile stability tests have also been made on A sheet (see Table 4). Exposure at 100 F lowers yield strength to a greater degree than tensile strength.

Steels that are highly resistant to softening at temperatures around 1000 F can naturally be expected to be quite strong at these temperatures. The master tempering curves (for explanation, see previous article) in Fig 4 compare the hardnesses of steels A, D and E as they change with temperature (T) and time (t) of exposure. The differences in tempering characteristics of these alloys are due to differences in the alloying elements and in the ways in which they are combined in each steel. The chart shows that:

1. For D and E, a higher austenitizing temperature produces higher hardness at the higher parameters.

2. At low parameters, both of these steels have curves that remain essentially flat over a wide parameter range. This behavior is presumably due to the formation of different types of special carbides.

3. The curve for A assumes a negative slope more rapidly than the curves for D and E.

4. Steel E softens with increasing tempering time and temperature to a greater degree than D. At this stage, it appears, the special carbides have completely formed and they coalesce.

Hardness is often used as an indicator of other mechanical properties developed by a tempering cycle. The master tempering curves suggest that D is superior to E or A in hardness and strength after a period of elevated temperature service. This superiority is evident, for example, at a parameter of 34,700, which corresponds to tempering at 1000 F for 100 hr. The stability results given in Tables 4 and 5 show that D has higher tensile strength than A after these exposure conditions. This comparison indicates a qualitative relationship between room temperature hardness and tensile strength after extended exposures

TABLE 2—TENSILE STABILITY OF STEEL A BARS[a]

Exposure	Heat[b, c]	Tensile Strength, 1000 psi	Yield Strength (0.2% offset), 1000 psi	Elongation, %	Reduction in Area, %
As Heat Treated	K-L	207	186	15	45
	M	202	174	16	48
1000 F for 10 hr	K-L	197	176	16	45
	M	198	174	14	46
1000 F for 100 hr	K-L	182	158	15	46
	M	178	155	16	51
1000 F for 100 hr +1100 F for 10 hr	K-L	178	156	16	45
	M	168	148	17	50

[a] Tested at room temperature.

[b] Average properties given for heats K and L. Heats K-L: Bars of 1 in. square cut from 4.2 x 8.5 in. section. Heat M: Bars of 1 in. square cut from 4.0 x 2.5 in. section.

[c] Composition:

	C	*Mn*	*Si*	*Cr*	*Mo*	*V*
Heat K	0.38	0.36	1.05	5.12	1.32	0.33
Heat L	0.38	0.41	1.05	5.01	1.33	0.32
Heat M	0.38	0.34	1.06	4.90	1.36	0.33

TABLE 3—TENSILE STABILITY TESTS OF STEEL D BARS[a]

Exposure	Heat[b, c]	Tensile Strength 1000 psi	Yield Strength (0.2% offset), 1000 psi	Elongation, %	Reduction in Area, %
As Heat Treated	A-B	228	207	8.0	20
	C	222	201	10	30
1100 F for 10 hr	A-B	220	190	8.0	22
	C	216	198	9.5	27
1100 F for 100 hr	A-B	207	191	10	24
	C	200	180	10	30
1100 F for 100 hr +1200 F for 10 hr	A-B	200	182	10	25
	C	187	167	10	34
1275 F for 15 min	A	219	190	6.0	20
	C	204	187	11	32

[a] Tested at room temperature.

[b] Average properties given for heats A and B (except at 1275 F), Heats A-B: Bars of 1 in. square cut from 4 x 8 in. section. Heat C: Bars of 1 in. round processed from 3 in. square.

[c] Composition:

	C	*Mn*	*Si*	*Cr*	*Mo*	*W*	*V*
Heat A	0.55	0.35	0.31	1.46	1.75	2.63	1.35
Heat B	0.53	0.32	0.25	1.37	1.55	2.79	1.33
Heat C	0.53	0.30	0.35	1.39	1.58	2.74	1.40

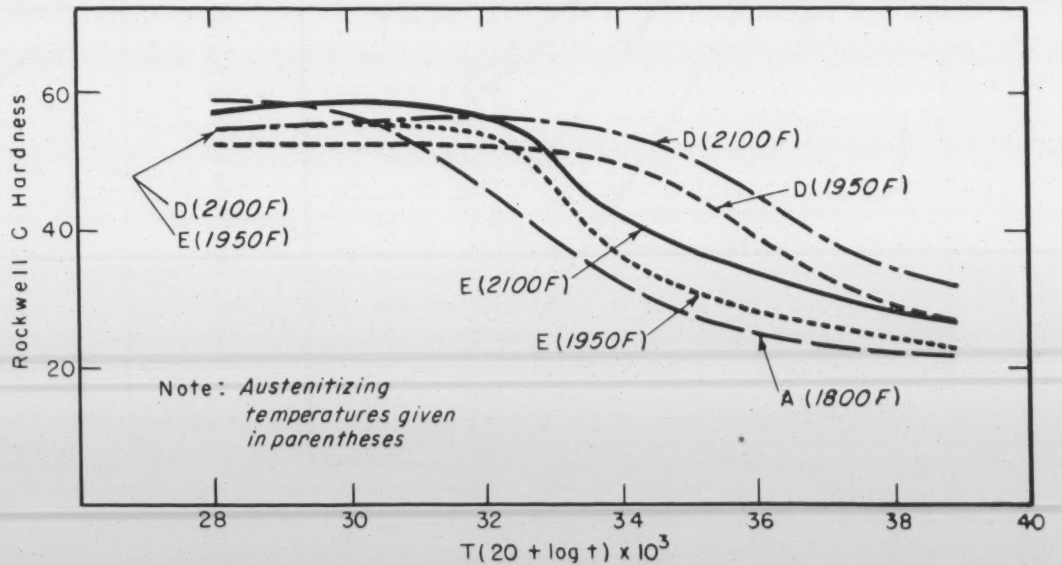


Fig 4—*Master tempering curves for steels A, D and E.*

at high temperatures. In general, each alloy has a characteristic temperature range in which properties are maintained over long exposures; at higher temperatures strength decreases with time.

Even though tensile strength holds up after prolonged exposure, ductility may be adversely affected. Loss of ductility may be reflected by an increase in notch sensitivity, the amount varying with the particular alloy. The effect of notches on the properties of these steels has not been determined.

TABLE 4—TENSILE STABILITY OF STEEL A SHEET[a]

Prior Exposure	Gage, in.[b]	Heat[c]	Tensile Strength, 1000 psi		Yield Strength (0.2% offset), 1000 psi		Elongation, %	
			Avg	Range	Avg	Range	Avg	Range
1000 F, 10 hr	0.102	A	184	183-185	151	150-152	11	10-12
	0.081	B	180	180-182	148	146-148	10	10-11
	0.071	A	181	179-182	148	148-149	10	9-10
1000 F, 100 hr	0.102	A	181	180-182	149	148-149	10	10-11
	0.081	B	176	175-176	144	143-144	9	9-10
	0.071	A	180	180-182	147	146-147	9	9-10

[a] Heat treated to 180-200,000 psi.

[b] Width 36 to 48 in.

[c] Composition:

	C	*Mn*	*Si*	*Cr*	*Mo*	*V*
Heat A	0.38	0.37	1.10	4.99	0.33	1.31
Heat B	0.38	0.37	1.09	4.88	0.33	1.31

3. Creep properties

During its service life, an airframe part may be subjected to various combinations of stress and heat. Where the design is based on peak stresses, the maximum stresses for these steels in a certain time interval, i. e. the stresses required to produce strength and tempering stability, can be expected to correlate with the short time data already discussed. Where cumulative deformation is important, however, the appropriate design criterion is the stress to produce a given amount of strain in a given time, e. g., the stress required to produce 0.2% deformation in 500 hr.

Fig 5 shows stress-strain curves for steel E at room temperature and at 1000 F, and schematic isochronous (constant time) stress-strain curves for 100 and 1000 hr at 1000 F. The relationship of the isochronous curves to the stress-strain curves is such that the stresses at which the isochronous curves deviate from the short time stress-strain curve are the stresses at which creep becomes an important factor under the conditions of time and temperature for which the isochronous curves were prepared. In an aircraft operating at supersonic speeds, where aerodynamic heating occurs, design must be based on the isochronous rather than on the com-

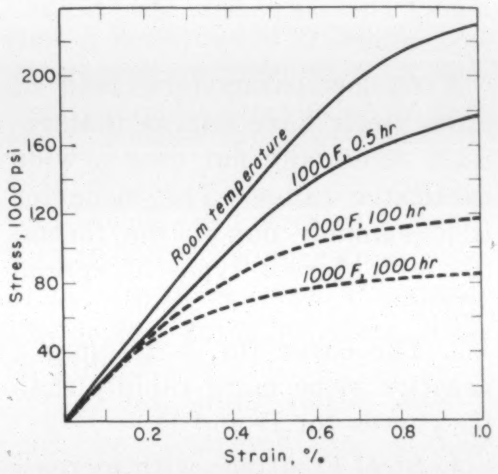


Fig 5—*Stress-strain curves at room temperature and schematic isochronous stress-strain curves at 1000 F for steel E heat treated to Rc 51.*

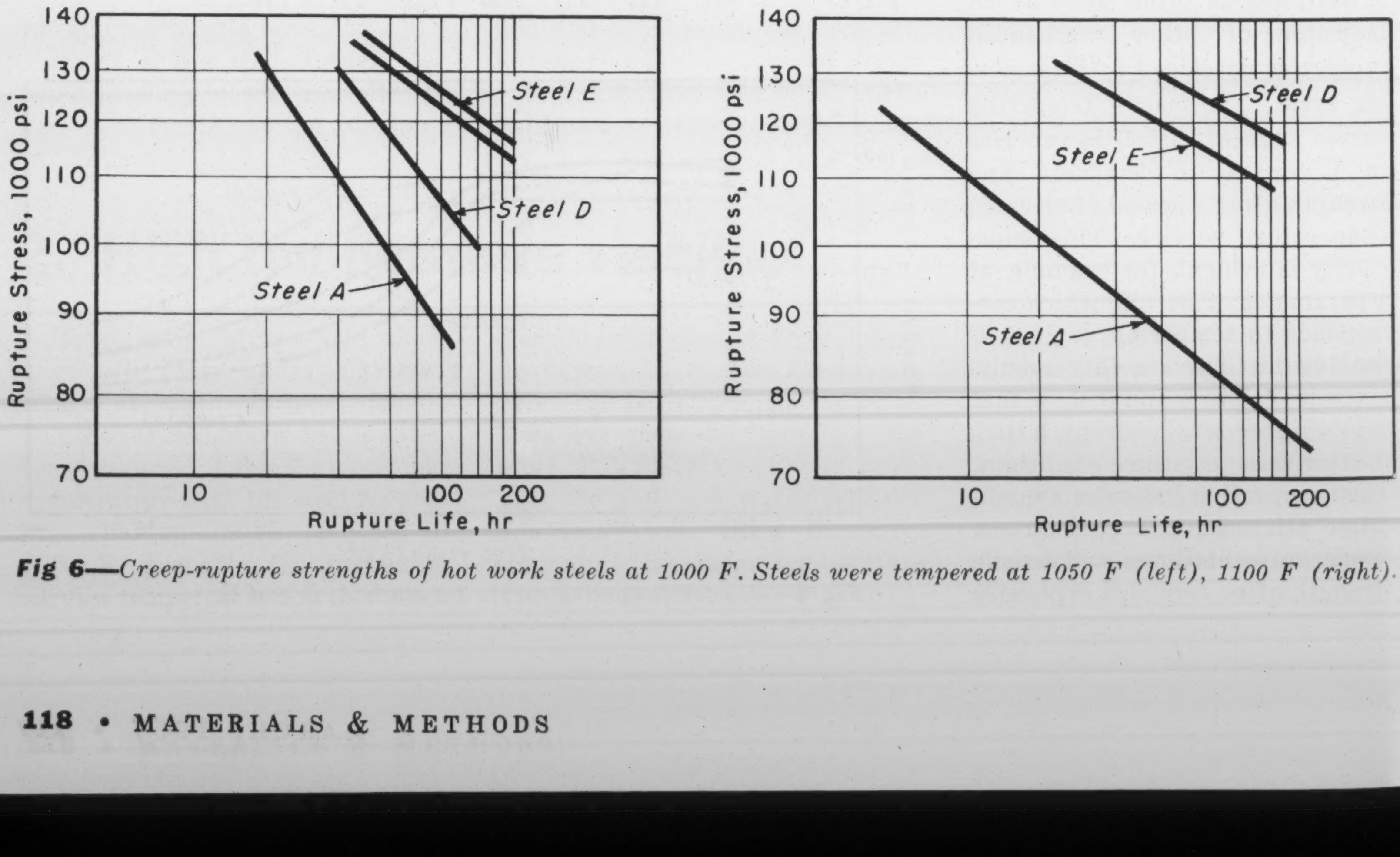


Fig 6—*Creep-rupture strengths of hot work steels at 1000 F. Steels were tempered at 1050 F (left), 1100 F (right).*

mon yield strength curves.

Stress rupture data on steels A, D and E at 1000 F are plotted for two tempering temperatures in Fig 6. Steel E is equivalent to D (i. e., the curves are close enough to indicate that property bands would overlap in actual practice) and superior to A when all three steels are tempered at 1050 F (Rc 52 hardness). Based on strength and rupture ductility, E shows the most favorable combination of properties and, therefore, would be selected over D. Rupture values for steel A sheet heat treated to 180-200,000 psi are given in Fig 7.

The data on steels D and E indicate that resistance to softening upon heating is not necessarily directly related to creep rupture. In Fig 4, D was shown to be more resistant to softening at elevated temperatures than E. When these steels are tempered at 1100 F (Rc 47 for E, Rc 52 for D), D has the higher rupture strength at 1000 F. But when both steels are tempered at 1050 F (Rc 52 hardness), E has the higher rupture strength at 1000 F.

The short time tensile and stress rupture values for these steels at 1000 F compare favorably with the values obtained for superalloys. D and E bars have tensile strengths of 187,000 psi and 199,000 psi at 1000 F, compared with 118,000 psi, 142,000 psi and 131,000 psi for the superalloys S-816, Inconel X and A-286, respectively. The 100 hr at 1000 F creep rupture value of 126,000 psi for E is higher than that of any material reported in the literature. The values for S-816, Inconel X and A-286 are only 120,000 psi, 118,000 psi and 100,000 psi. The 1000 hr at 1000 F rupture of 76,000 psi for E is still close to the range of values obtained for the superalloys.

In addition to its high rupture strength, E has rupture elongation ranging from 8 to 11%. D is rather brittle and ruptures with only 1 to 2% elongation in all tests, whereas A ruptures with high elongation, ranging from 6 to 15%. Since the amount of deformation at rupture is variable, creep rupture data must always be used with a safety factor.

Recommended Heat Treatments

Proper heat treatment is important in attaining desired mechanical properties. In particular, it is important to consider the effects of austenitizing and tempering temperatures and of composition variations.

The most successful heat treatment for steel A bars and forgings requires:

1. Heat 100 deg per hr from 1200 to 1800-1850 F.
2. Soak at temperature for a minimum of 1 hr.
3. Quench and equalize in salt at 800 F.
4. Air cool to 150 F.
5. Double temper at 1050 F ± 25 F for 4 hr, air cooling in each case.

Resulting bar properties exceed minimum longitudinal values of 200,000 psi ultimate strength, 170,000 psi yield strength, 10% elongation, 30% reduction of area, and 12 ft-lb Charpy V-notch.

For A sheet the recommended heat treatment is:

1. Heat the material 30 min at 1825-1850 F.
2. Quench and equalize in salt at 800 F for 5 min.
3. Air cool.
4. Double temper at 1100 and 1125 F for 4 hr, air cooling in each case.

Such a heat treatment has produced sheet properties exceeding 180,000 psi ultimate strength, 155,000 psi yield strength and 7% elongation.

Heat treatment of steel D requires an austenitizing temperature high enough to dissolve the complex alloy carbides and homogenize the austenite. For bars and forgings:

1. Preheat at 1400 F.
2. Heat to 1950 F and hold, the time depending on size.
3. Air cool.
4. Double temper at 1150 and 1225 F for 4 hr, air cooling in each case.

This treatment gives minimum longitudinal values of 200-230,000 psi ultimate strength, 175,000 psi yield strength, 8% elongation and 8 ft-lb Charpy V-notch. The 250,000 psi strength level is achieved by oil quenching from 1950-2100 F and tempering at 1150-1225 F. To date, transverse tensile ductility and impact values for steel D forgings have been quite low because heat treatments have not eliminated the directionality of alloy carbides.

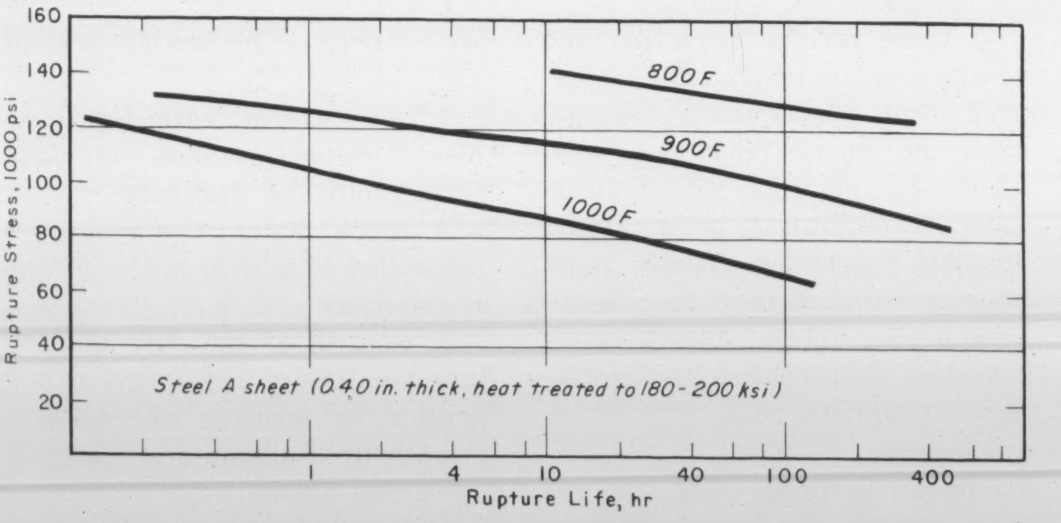


Fig 7—*Creep rupture strength of steel A sheet.*

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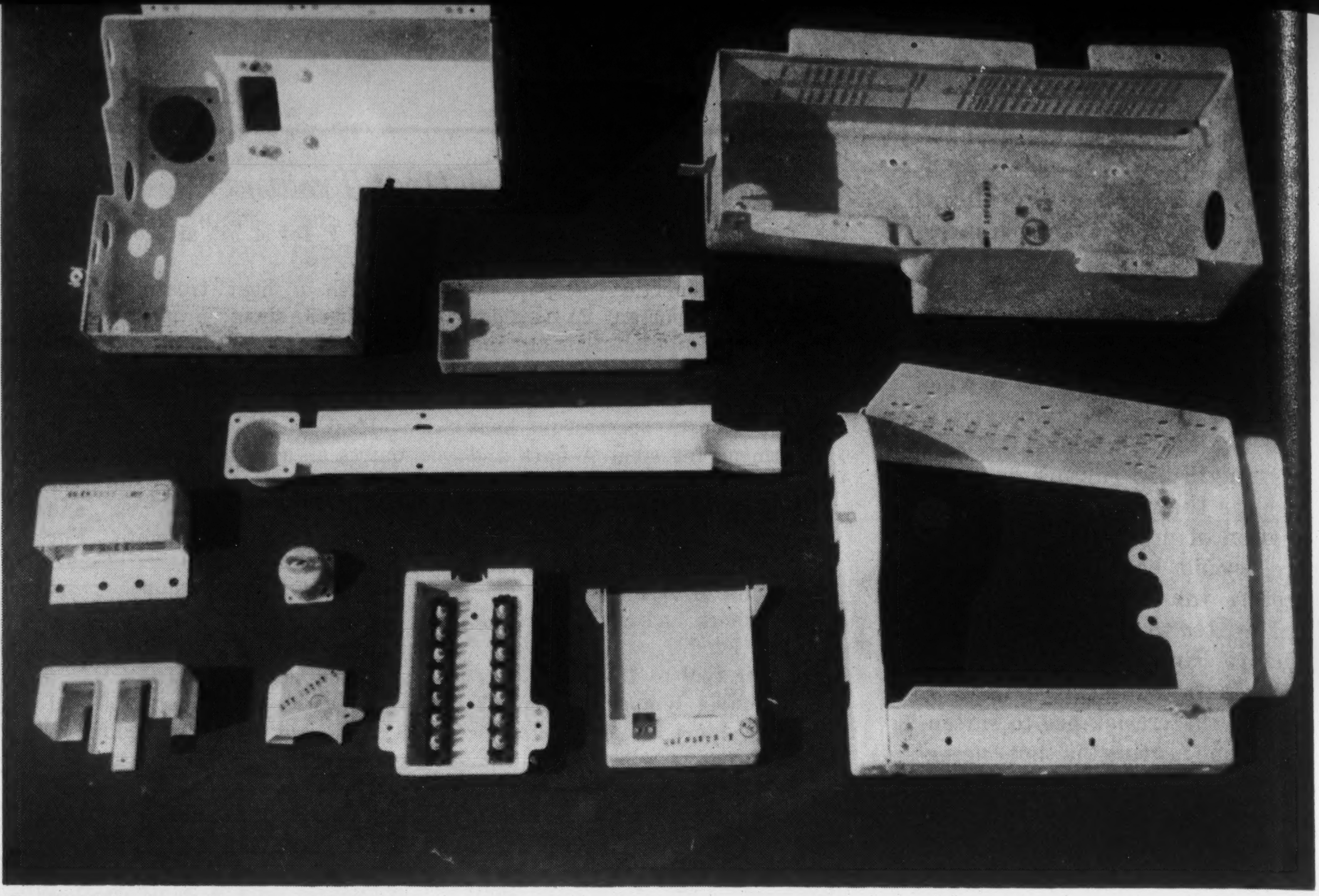


Typical parts *molded from prepregs.*

Why Specify Prepregs

for Reinforced Plastics Parts?

These laminating materials are used more and more widely by reinforced plastics molders to improve quality and simplify fabrication. Here is an up-to-date report which includes a discussion of the most important glass-reinforced prepregs now available.

by W. Brenner, *Consultant, and* **H. J. Duprez,** *Wallace & Tiernan, Inc.*

■ The advantages of using prepregs stem from the fact that they are "pre-engineered" reinforced plastics purchased as one material. The resin system has been carefully prepared with proper proportions of components, such as hardeners, fillers and catalysts, and the predetermined resin-reinforcement ratio has been maintained consistently throughout the material. This pre-engineering simplifies fabrication and provides parts of more predictable quality.

A wide variety of resins and reinforcements is available in prepreg form. Consequently, the specifier can choose from many materials having different combinations of mechanical, electrical and physical properties. Where stock prepregs will not meet specific design needs, special formulations can often be prepared by the materials suppliers.

Advantages

Use of prepreg materials results in parts of higher reproducible quality than those formed by wet lay-up. The major reasons are:

1. A uniform resin-reinforcement proportion can be kept throughout the laminate.
2. Resin content can readily be controlled to within ±3%, or less if required.
3. Control of the cure is absolute because of the uniform dispersion or solution of carefully premeasured amounts of catalysts or curing agents.
4. Trapped air pockets or minute air bubbles in the lamina

are eliminated. Trapping of air during mixing of resin systems for wet lay-ups is often a major problem; pockets are cause for rejection of parts, and minute bubbles detract seriously from the quality of the part.

5. Since prepregs are predried, moisture, which has a deleterious effect on laminates, is eliminated.

The most substantial benefit from using prepregs is the resulting simplification in molding operations. Use of only one material containing both the resin and the reinforcement eliminates such steps as compounding and control of resin-reinforcement ratio. Prepreg moldings are prepared by cutting, slicing or stamping suitably sized blanks from sheets or rolls of prepreg, stacking the blanks to the desired thickness and molding. For simple shapes roll material can often be fed directly into the molding dies. This process results in 1) cleaner molding operations, eliminating clean-up necessary after wet molding, 2) less waste, since there is no spillage or mold overflow, 3) less hand labor, and 4) reductions in storage and materials handling costs, since only one material must be stored and moved. Additional fabrication benefits derive from the simplified control of quality and production.

Materials available

Most prepregs make use of glass cloth or mat; hence, most of this discussion deals with glass-reinforced materials. Other fiber reinforcements available include synthetics such as nylon, Dynel, Orlon and Dacron, and natural materials such as paper, sisal, jute, cotton duck and linen. Some work has also been carried out with acetates, and some prepregs with asbestos reinforcement are commercially available. (Properties obtained with asbestos prepregs were discussed in M&M, Feb '56, p 103.)

A large number of resins are available in prepreg form. The more common ones are polyesters, DAP (diallyl phthalate), epoxies, phenolics and silicones (see Table 1 on the following page).

Polyester, DAP—The most commonly used prepregs consist of polyester, DAP or DAP-modified polyester resin and glass cloth. In general, these materials provide a colorless, sometimes translucent, high density laminate after a relatively short cure at low temperatures. Mechanical, electrical and chemical properties are usually adequate for most common applications.

Disadvantages of such prepregs are: 1) high (4-8%) shrinkage during cure, resulting in relatively poor surfaces and poor water resistance, 2) relatively low service temperature limit, except for TAC-modified polyesters, and 3) questionable storage life.

Prepregs: What They Are

A prepreg material is generally defined as a combination of semi-cured or "B stage" resin and continuous sheet or web type reinforcing material. It is usually purchased in roll form ranging up to 72 in. in width, or wider if desired. Though it cannot be considered a new development, since prepregs have been used for some time in high pressure laminating, the use of 100% polymerizable low pressure polyester and epoxy resins and B staged phenolics with glass fiber reinforcements has broadened the field of application for reinforced plastics parts.

The distinction between prepregs and so-called premix molding materials lies primarily in the character of the fibrous reinforcements. Whereas prepregs make use of essentially continuous reinforcements such as cloths or mats, premix molding compounds are formulated with discontinuous reinforcements such as chopped fibers and chopped rovings. Thus, prepreg moldings are produced by laying up layers of prepreg and molding to shape, whereas premix moldings are made by charging a mold with the material in bulk form and molding to shape.

Such laminates are used in helicopter stabilizers, aircraft ducting, electrical insulating boxes, containers and fairings.

Epoxy — Epoxy-glass prepregs are relatively new, but have aroused considerable interest. They provide low shrinkage during cure; excellent mechanical, electrical and chemical resistance properties; low water absorption; and excellent dimensional stability. Though they are higher in cost than phenolics or polyesters, the price differential in impregnated form is negligible for most purposes.

Epoxy prepregs can be "tailored" to provide high or low flow, drape, tack and other handling properties. They also have excellent storage life and are suitable for both high and low pressure molding.

Disadvantages of epoxy prepregs are extreme adhesion to mold surfaces and slightly longer cure cycles at higher temperatures than the polyesters or phenolics. Also, temperature resistance is relatively poor, though current development work promises improvement. Such materials have been used primarily in printed circuits, tubular goods, ducting and plastics tooling.

Phenolics — Future growth in use of phenolic-glass prepregs is expected to be primarily in high temperature applications. Phenolic prepregs cure to form laminates with high mechanical strength, good electrical properties and good chemical resistance. They are relatively low in cost and can be molded with either high or low pressure techniques. One of the major advantages of phenolic prepregs is the variety of properties which can be "built in" during the B-stage process (i.e., the preliminary cure). Flow, drape, tack and other properties can be varied to meet specific design needs.

Major limitations of phenolic prepregs are poor colorability and color control, and problems arising from the by-products of the condensation reaction. After the resin has been advanced to the B stage, it has a volatile content of from 2-5%, of which 90% is water. During the final cure, some volatile matter remains trapped in the laminate in the form of gas. Thus, it is difficult to produce translucent, void-free laminates. Though you might expect these gas pores to be a serious limitation, recent work indicates that their presence helps maintain strength at high temperatures. The gas pockets tend to relieve the stresses resulting from the difference in expansion rates of the resin and the glass.

Silicone — Silicone-glass prepregs are specialty materials designed for use where properties must be retained after prolonged exposure to high temperatures (500 F or higher). Laminates have high dielectric properties and relatively good mechanical strength. They can be molded by high or low pressure techniques, but must be postcured to attain optimum strengths. Recent work has indicated that specially designed finishes for the glass reinforcement can substantially improve the mechanical strength of silicone-glass laminates.

Silicone prepregs are supplied in the B stage and, as in the case of phenolics, volatile by-products are given off during the cure. The B staging of silicone resins is a critical operation and has a definite effect on strength of cured laminates. Silicone prepregs are generally dry and stiff, and solvents evaporate rapidly when the material is exposed to room conditions. New packaging procedures are being investigated in an attempt to increase volatile retention and thereby improve drape.

Major disadvantages of silicone prepregs are high cost, low initial mechanical strength, difficulty in handling, extensive postcure at relatively high temperatures, and critical curing conditions.

Other—Use of melamine-glass prepregs is limited, and confined primarily to electrical equipment. Melamine prepregs are molded at high pressures, and resulting laminates have high initial strength and good dielectric properties. Such materials are relatively high in cost.

Other resins have been investigated for possible use in prepregs. They include vinyl copolymers, styrene "alloys" and fluorocarbons. As yet, they have not been used in appreciable quantities.

Molding methods

Prepreg materials can be molded by matched metal techniques, pressure bag or vacuum bag molding, or mandrel wrapping. The majority of parts molded from prepregs today are formed by matched metal molding. Choice of mold materials depends largely on the type of part to be made and the quantities involved. Aluminum molds are widely used because of their moderate materials cost, ease of machining and light weight. Pinch-off type molds have been used effectively in several applications. In designing, it is important to recognize the limited flow of prepreg materials and to provide for mold venting as required by geometry of the

TABLE 1—GENERAL COMPARISON OF GLASS-REINFORCED PREPREGS[a]

	Polyester and DAP	Phenolic (general purpose)	Phenolic (temperature resistant)	Silicone	Epoxy
Flexural Strength, 1000 psi[b]					
Room Temperature	55-65	73	65-75	42.3	85
½ hr at 500 F	—	—	45-55	15	10 (at 300 F)
½ hr at 700 F	—	—	40	14	—
100 hr at 500 F	—	—	14-17	15	—
200 hr at 500 F	—	—	—	16	—
2 hr in Boiling Water	45-58	69	56-70	—	75
Modulus in Flexure (initial), 10^6 psi	2.6	3.3	3.1	2.88	3.7
Ultimate Tensile Strength, psi	49,000	45,000-50,200	50,000	40,600	54,000
Ultimate Compression Strength, psi	40,000	46,000-51,500	35,000	21,300	60,000
Barcol Hardness	—	72	—	73	61
Specific Gravity	1.80	1.85	1.53-1.95[d]	1.91	1.85
Flammability[c]	Burns slowly	Self-extinguishing	Self-extinguishing	Nil	Burns slowly
Arc Resistance, sec	—	200	—	250	246
Color	Almost colorless	Straw yellow to brown	Straw yellow to brown	White opaque	Almost colorless
By-Products of Cure	No	Yes	Yes	Yes	No
Major Advantages	No by-products, good color	Good general properties, low cost	Heat resistance, low cost	Heat resistance	Low shrinkage, excellent physical and electrical properties
Major Limitations	Cure time and cost	Limited colors	Low strength after long exposure to high temperature	High cost	Poor mold release, 250 F max service temperature

[a] Reinforcement: 181 Volan A cloth, except silicones which were prepared with 181 cloth with no finish.

[b] Tested at temperatures indicated.

[c] Flammability ratings based on unmodified resin laminates. All can be modified to give greater resistance.

[d] Higher densities based on vacuum bag laminates.

part. Typical cure conditions are shown in Table 2.

The optimum resin content of prepreg materials is in the 30-40% range. Depending on the molding operation used, however, it may be necessary to compromise between strength and flow in determining the resin-reinforcement ratio. High pressure moldings can be obtained with prepregs containing about 30% resin. With vacuum or pressure bag techniques, a prepreg with a higher resin content should be used.

Considerable work has been carried out on mandrel wrapping of prepregs. Wrapping is generally carried out under tension using conventional equipment. Cellophane or polyvinyl alcohol external wraps are often used. Cure is carried out either in an air circulating oven or under infrared heaters.

New developments

There are several areas in which development work to date indicates promising prepreg materials in the future. A considerable amount of work is being done in developing more heat resistant materials, particularly epoxies and phenolics. Certain phenolic prepregs under development can successfully withstand 500 F service for considerable periods of time. An experimental, modified silicone prepreg retained useful strength after prolonged exposure to temperatures as high as 750 F.

Prepregs having low electrical losses, required in certain electronic applications, are also being developed. Divinyl benzene-cross-linked styrene resins using Dacron reinforcements are under study. Such laminates have attained dielectric constants of less than 3.

Reinforcement with materials other than glass has received increasing attention. Thermoplastic fibers, for example, provide useful combinations of properties. Such materials provide much better flow characteristics during molding because of the thermoplastic behavior of the reinforcement. Nylon has been used in the nonmetallic armor program and may find additional applications. The superior chemical resistance of Dynel provides additional protection in parts exposed to severe environments.

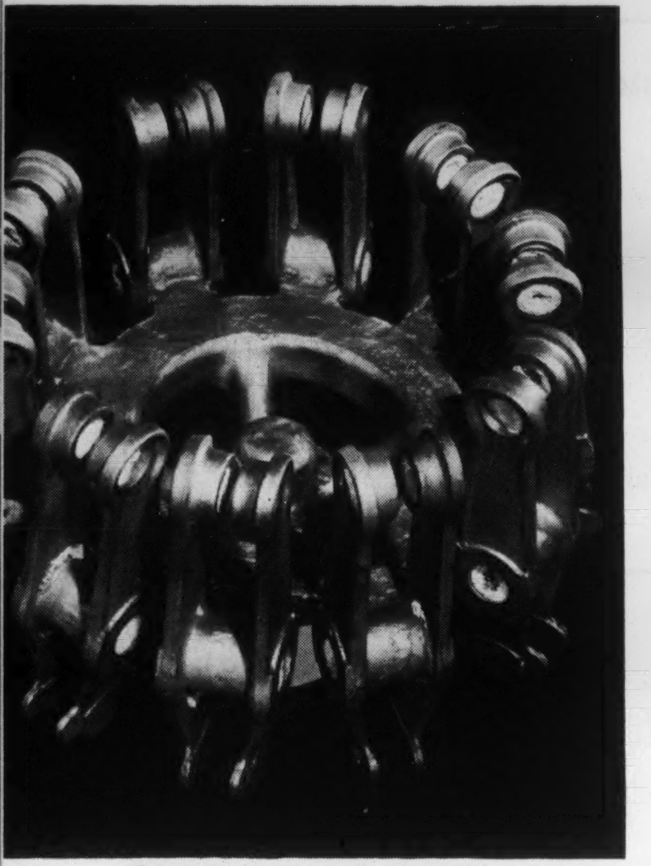
Prepregs are supplied by . . .

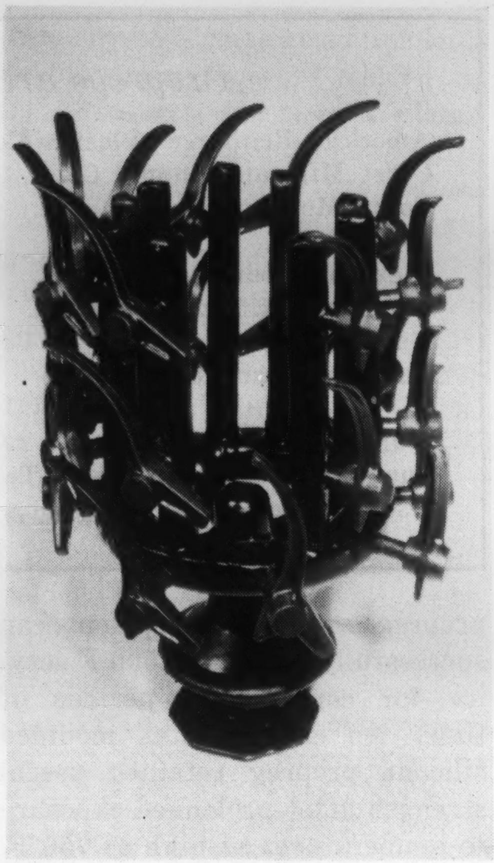
American Reinforced Plastics Co.	——
Coast Mfg. and Supply Co.	F–
Cordo Molding Products, Inc.	Cordopreg Mobaloy
Flexfirm Products, Inc.	Flexfirm
Minnesota Mining & Mfg. Co.	Scotchply
Narmco Resins and Coatings Co.	Narmcloth
Raybestos-Manhattan, Inc.	Pyrotex Novabestos
Standard Insulation Co.	Stanpreg
Sun Chemical Corp., Electro-Technical Products Div.	Sunform
U.S. Polymeric Chemicals, Inc.	——

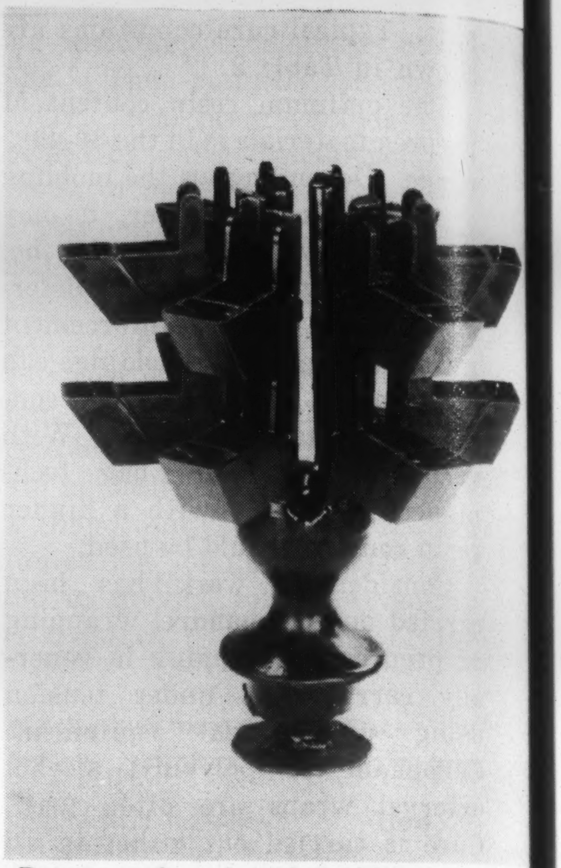
Adapted from a paper presented at the 12th Annual Conference of the Reinforced Plastics Div., Society of The Plastics Industry, Inc., Feb '57.

TABLE 2—TYPICAL CURING PROCEDURES
(1/8 in. Laminates)

Type of Laminate	Vacuum Bag (oven cure)		Positive Pressure		
	Cure	Post-Cure	Pre-Cure	Cure	Post-Cure
DAP, Polyester	15 min at 150 F	None	None	10-30 min at 310 F	None
Phenolic	½ hr at 250 F +½ hr at 300 F +½ hr at 350 F	½—1 hr at 325-375 F	0-2 min at 325 F (contact pressure)	30 min at 325 F or 45 min at 300 F or 1½ hr at 275 F	½—1 hr at 325-375 F
High Temperature Phenolic	½ hr at 200 F +½ hr at 250 F +½ hr at 350 F	1 hr at 360 F +1 hr at 425 F +5 min at 500 F	½ min at 325 F (contact pressure)	30 min at 325 F (10 psi)	1 hr at 360 F +1 hr at 425 F +5 min at 500 F
			None	2 hr at 350 F (200-500 psi)	1 hr at 360 F +1 hr at 425 F +5 min at 500 F
Silicone	10 min at 250 F +2 hr at 350 F	16 hr at 200 F +2 hr at 250 F +2 hr at 300 F +2 hr at 350 F +2 hr at 400 F +2 hr at 440 F +12-48 hr at 480 F	2-3 min at 350 F (contact pressure)	30 min at 350 F (30-200 psi)	16 hr at 200 F +2 hr at 250 F +2 hr at 300 F +2 hr at 350 F +2 hr at 400 F +2 hr at 440 F +12-48 hr at 480 F
Epoxy	1 hr at 350 F	Bone	2-4 min at 350 F (contact pressure)	30 min at 350 F (30-500 psi)	None


Stainless toggle levers


Stainless trip figures


Brass carbon brush holders

Investment 'X' Castings

made by a new process . . .

■ Investment casting has long been known as an accurate and efficient method of producing intricate parts. Several different investment processes are now in existence, each offering distinct advantages. The latest modification is the Investment X Process. This process differs from the conventional, solid mold, "lost wax" method in two ways: 1) the wax pattern assembly is invested with up to eight coats, and 2) the wax is removed by immersion in trichloroethylene vapor, rather than by melting. Because the wax is dissolved instead of melted out, it is possible to produce larger castings without fear of mold cracking. Although the largest casting made so far weighs 56 lb, there is theoretically no limit on the size of castings possible. Chief limitations of the process are the cost and handling problems associated with toxic trichloroethylene.

. . . which has these advantages

1. Larger castings are possible. Since wax is not melted out by heat, there is negligible expansion. As a result, there is practically no limit on mass of wax used and, consequently, on size of casting.

2. Greater mold permeability. Because molds are actually a series of built-up shells rather than solid investment, they are highly porous.

3. Mold cracking is eliminated. Main cause of mold cracking is expansion in wax removal. In Investment X process wax is removed by solution rather than by heat. Permeability of mold also minimizes effects of whatever expansion forces exist.

4. Lower pouring temperatures. Greater permeability of molds permits adequate fill with colder pouring.

5. Better wax removal and recovery. It is much easier to immerse molds in trichloroethylene than to subject them to heat. Also, wax is recovered from solution bath and reused.

6. Hollow wax patterns are feasible. Since molds are built up by dipping, no excessive pressure is put on molds by slurry.

This article is based on two reports by J. S. Turnbull, Metropolitan-Vickers Electrical Co., Ltd., England, and information supplied by Shaw Process Development Corp., Port Washington, N. Y.

How the process works

1. Wax pattern is dipped in slurry . . .

Insofar as wax patterns are concerned, Investment X process is identical with solid mold "lost wax" process, and same injection machinery can be used. Dipping makes possible even coatings of ethyl silicate-bonded slurry on the patterns, resulting in uniform surface finish on castings. Dipping also provides stronger, more permeable shells. Rotating bowl and stirrer are used to maintain consistency of slurry.

2. then showered with molochite . . .

Starting with second dip coat, shell is showered with molochite in stucco-rain machine to insure that each coat will mechanically bond to previous one.

3. and tunnel dried . . .

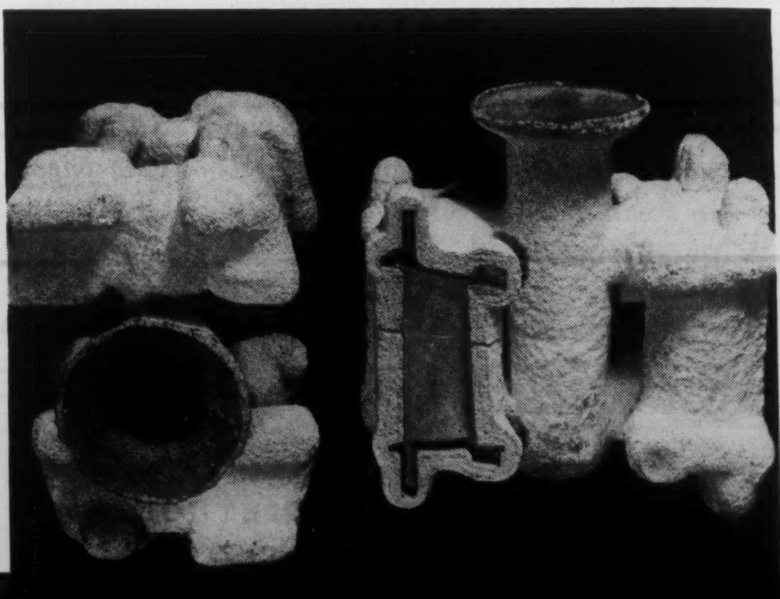
After stuccoing, shell passes through drying tunnel. Majority of patterns receive six dip coats; large patterns receive eight coats. Thickness of complete shell is about ¼ to ½ in.

4. Wax is removed . . .

When pattern has enough coats, wax is removed by immersion in trichloroethylene vapor. Vapor permeates porous shell and immediately dissolves wax faces adjoining investment before heat of vapor expands wax. Mold of 15 lb capacity can be completely dewaxed in 30-45 min.

5. and mold is ready for firing.

When mold is completely dewaxed, it is packed in stainless container filled with granular refractory, usually a mixture of sand and molochite, and baked in gas-fired conveyor furnace. During baking cycle, the sand frits. When molten metal is poured into mold and cools to room temperature, sand unfrits and eases problem of pouring. Shell investment is then separated from casting by vibration.



Sharon Steel Corp.
Midvale-Heppenstall Co.

1. Steel manufacture

Melting, pouring and solidification to ingots and castings—Requires control of chemical composition, cleanliness, satisfactory deoxidation practice, soundness, uniformity, minimum segregation and freedom from internal defects

Hot working to billets, blooms and forgings—Requires plasticity and formability at hot working temperatures, and freedom from internal and surface defects

2. Conversion to piping

Hot working to pipe—Requires plasticity and formability at hot working temperatures and freedom from internal and surface defects

Heat treatment — Requires capability of being heat treated to produce properties needed by fabricator

Consider these factors in selecting . . .

Steam Piping Materials for

The trend toward higher operating temperatures and pressures in steam power plants calls for a reappraisal of current piping materials. This article discusses present materials and new alloys now under development.

by H. S. Blumberg, *Consulting Metallurgist**

■ Above are listed the important requirements that must be met by materials used for high temperature, high pressure steam piping. As the chart suggests, the designer must be cognizant of the complete cycle through which the alloys pass—from their origin in steel melting to their operation in steam plant service.

Requirements

Throughout their life span, piping materials are subjected to various conditions of temperature, time, heating and cooling, hot and cold work, etc., each of which is instrumental in determining end properties. The importance of temperatures in determining the properties of ferritic and austenitic steel piping in each of the four phases of their life cycle is seen in the chart on page 129.

Adequate end-service properties is the most important design factor in selecting piping materials. A metal cannot be considered unless it possesses freedom from embrittlement and sufficient high temperature strength for long time periods to permit the use of reasonably thin walls. Heavy-walled pipes promote stiffness, tridimensional stress, and severe thermal stresses across the wall with rapid temperature changes, possibly resulting in cracking and failure. Even though a piping material meets the requisite service conditions, however, it must also meet the requirements of the first three materials processing phases.

The capability of weld joints is especially important. Weld deposit compositions are not always identical with the base metal and analyses selected often represent compromises in which a primary

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* *Formerly Chief Metallurgist, M. W. Kellogg Co.*

3. Fabrication

Hot bending — Requires plasticity and formability, including suitable strength at hot working temperatures

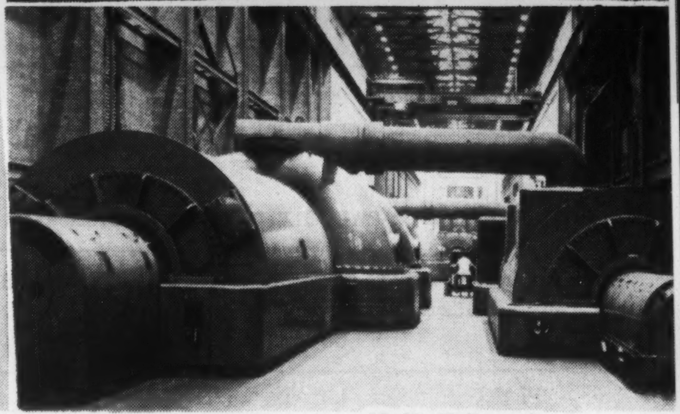
Heat treatment — Requires capability of being heat treated to produce properties needed for service

Welding—Requires capability of being joined with satisfactory qualities in weld, heat affected zone and base metal

Post heating—Requires satisfactory hardness, ductility and metallurgical structure

4. Service

Exposure to high temperatures, high pressures and high steam flow rates—Requires good rupture strength; stability of ductility properties, metallurgical structure and surface; and retention of original room temperature properties during shutdown periods



M. W. Kellogg Co.
Consolidated Edison Co. of New York, Inc.

High Temperature Service

aim is to insure sound welds and freedom from cracking in fabrication (welding and heat treatment) and service. Piping weldments have various types of metallurgical structures, and the designer must be aware of their effects in the specific metals used.

Materials currently used

Experience gained in the oil and chemical processing industries has been of great value in developing steels for high temperature, high pressure steel piping. The power industry, using the ferritic low chromium-molybdenum steels as a base, has further developed and modified them to suit steam plant requirements, generally standardizing on the ferritic and austenitic alloys listed in Table 1.

Ferritic steels have had an excellent record as steam piping during more than ten years of modern high temperature conditions, including operation up to 1050 F. As shown in Fig 1, a marked metallurgical advantage of these steels is their full response to heat treatment above the critical range. This makes possible weld joint microstructures that are quite similar to those of the parent piping. Despite these advantages, however, the ferritic steels are deficient in surface stability (oxidation resistance) and rupture strength for the high temperatures now being contemplated.

Austenitic stainless steel was first used approximately nine years ago when type 347 was selected by turbine manufacturers for use at 1050 F and 1500 psi. At that time the ASME Boiler Code had recognized four austenitic chromium-nickel stainless steels for service at elevated temperatures: 304, 347, 321 and 316. Currently, maximum allowable stresses for these steels at 1050 F are 13,100 psi for types 347 and 321, 12,200 psi for type 316 and 10,000 psi for type 304.

Although the columbium-bearing 347 alloy was originally developed for its outstanding corrosion resistance at ordinary and elevated temperatures, it also possesses excellent oxidation resistance and strength at high temperatures. Unlike the carbon steels, the austenitic steels cannot be grain refined, since they possess no critical range. Also, these steels are subject to potentially embrittling phase changes which tend to lower some properties. However, certain advantages of the austenitic high temperature steels are so outstanding that designers must use them if operat-

TABLE 1—CURRENTLY USED PIPING MATERIALS

ASTM Class No.	Chemical Composition (approx), %					ASME Allowable Stress, psi						Recommended Temperature Range, F
	Cr	Mo	Ni	V	Cb	950 F	1000 F	1050 F	1100 F	1150 F	1200 F	
Ferritic												
1	—	0.5	—	—	—	8500	5500	—	—	—	—	Below 850
12	1.0	0.5	—	—	—	11,000	7500	5000	2800	1550	—	825-950
11	1.3	0.5	—	—	—	11,000	7800	5500	4000	2500	—	825-1000
22	2.3	1.0	—	—	—	11,000	7800	5800	4200	3000	2000	950-1050
21	3.0	1.0	—	—	—	9000	7000	5500	4000	2700	1500	Up to 1000
—	1.0	1.0	—	0.2	—	—	10,000[a]	8500[a]	6000[a]	—	—	Up to 1050
Austenitic												
347	18.0	—	12.0	—	8 x %C min	13,850	13,500	13,100	10,300	7600	5000	Above 1050
316	16.0	2.0	13.0	—	—	15,100	14,000	12,200	10,400	8500	6800	Above 1100

[a] Under consideration but not yet approved by ASME.

TABLE 2—COMPOSITION AND PROPERTIES OF PROMISING PIPING MATERIALS[a]

Grade	Composition, %							Estimated Allowable Stress at 1200 F, psi[b]
	Cb	Cu	Co	W	Ti	N	Fe	
15-15N	1.0	—	—	1.5	—	0.15	60	11,400
17-14 copper-molybdenum	0.5	3	—	—	0.5	—	62	12,000
G18B	3	—	10	2.5	—	—	53	10,500
N155	1	—	20	2.5	—	—	30	9900

[a] Chromium, nickel and molybdenum contents are roughly similar to those of type 316 stainless steel.

[b] Based on limited data. Should not yet be used in design.

ing temperatures and pressures continue to increase.

The lighter wall thicknesses permitted with the higher strength austenitic alloys reduce some of the usual difficulties encountered in fabrication and service. Some cracking at welded joints has been encountered in type 347 piping. However, recent work indicates that this problem can probably be eliminated.

Currently there are 24 power stations in this country in various stages of design, construction and operation which have been designed for operation at temperatures of 1050 F and above. Of these, 18 utilize type 347 stainless steel piping between the stop valves and the turbine, and four use type 347 for station piping between the boiler and the stop valves.

Type 316 austenitic stainless steel has not been used as main steam piping in actual power plant service. It has, however, been selected for five new stations designed for use at 1100 F and above, including the 1200 F, 5000 psi Eddystone unit scheduled for completion in 1958. Although considerable amounts of type 316 have been used, relatively little has been made as heavy-walled piping. Pressure vessels up to about 1 in. thick have been fabricated with no reported welding difficulties. It has been shown that types 347 and 316 can be welded satisfactorily under restraint in 3-in. pipe walls with either a matching or a 16-8-2 (see next paragraph) electrode. Of the combinations tested, type 316 base metal joints welded with 16-8-2 deposit appear to have the most satisfactory properties.

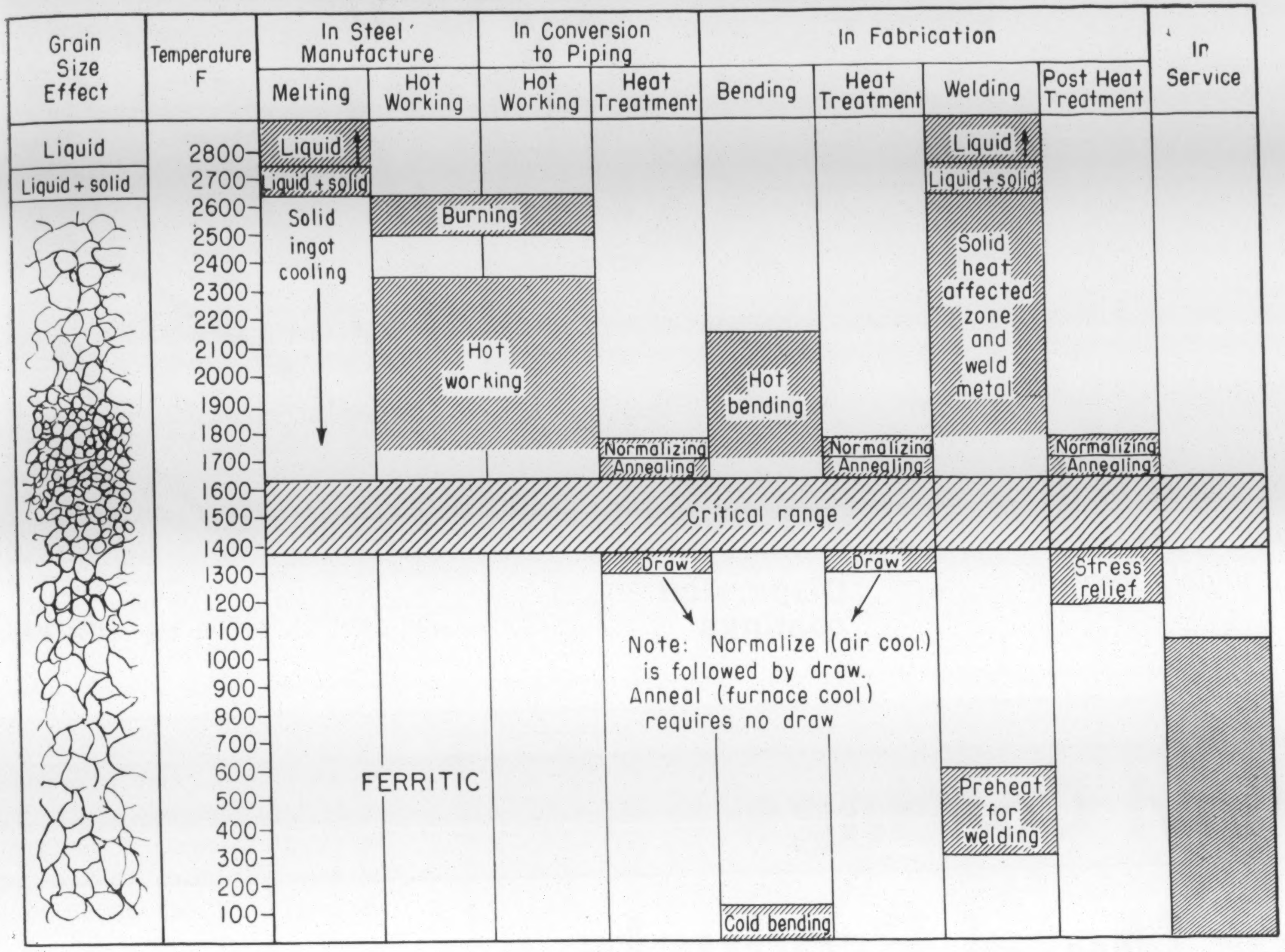
Latest developments

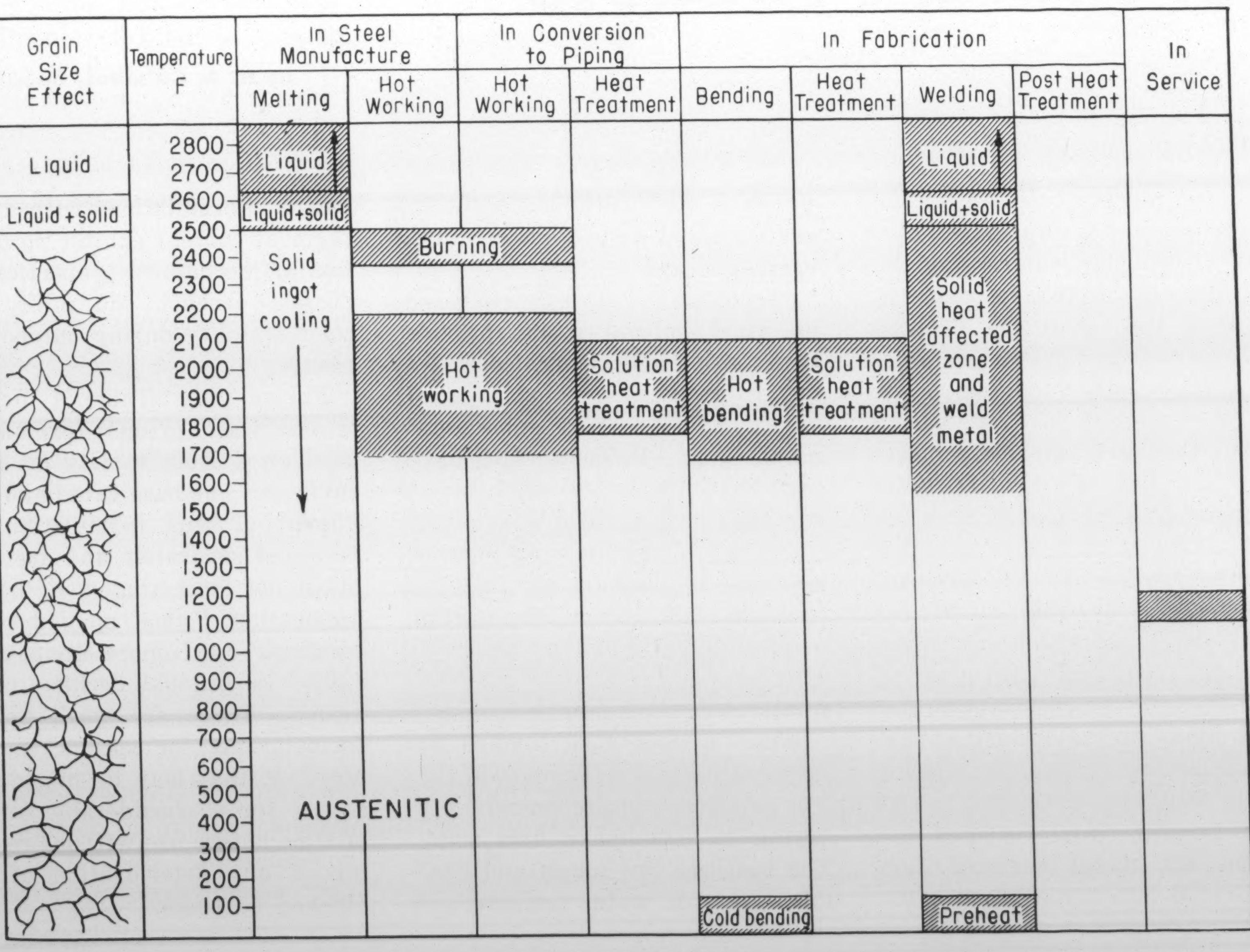
Designers are currently considering several new alloys developed especially for steam piping operating at high pressures and temperatures. The first specifically "new" material for high temperature service is the 16 chromium-8 nickel-2 molybdenum welding electrode. This alloy has shown considerably better hot ductility in stress rupture tests than conventional type 347 stainless. A number of welded joints using this alloy with type 347 base metal are being tested, and a program is under way to make wrought piping of the new alloy.

Some of the more promising alloys being developed for steam piping are listed in Table 2. These materials have roughly the same chromium, nickel and molybdenum contents as type 316 stainless steel, but also contain certain other alloying elements. None of these compositions is currently approved under the ASME Boiler Code. These, and a great many other high strength alloys, apparently have substantially greater long time stress rupture strengths at 1200 F and above than the 347 and 316 stainless steels. However, considerably more data are required on the stability and weldability of these alloys before they can be accepted for use. Of the various classes of high strength alloys, the chromium-nickel-iron and chromium-nickel-cobalt-iron alloys appear to be most promising.

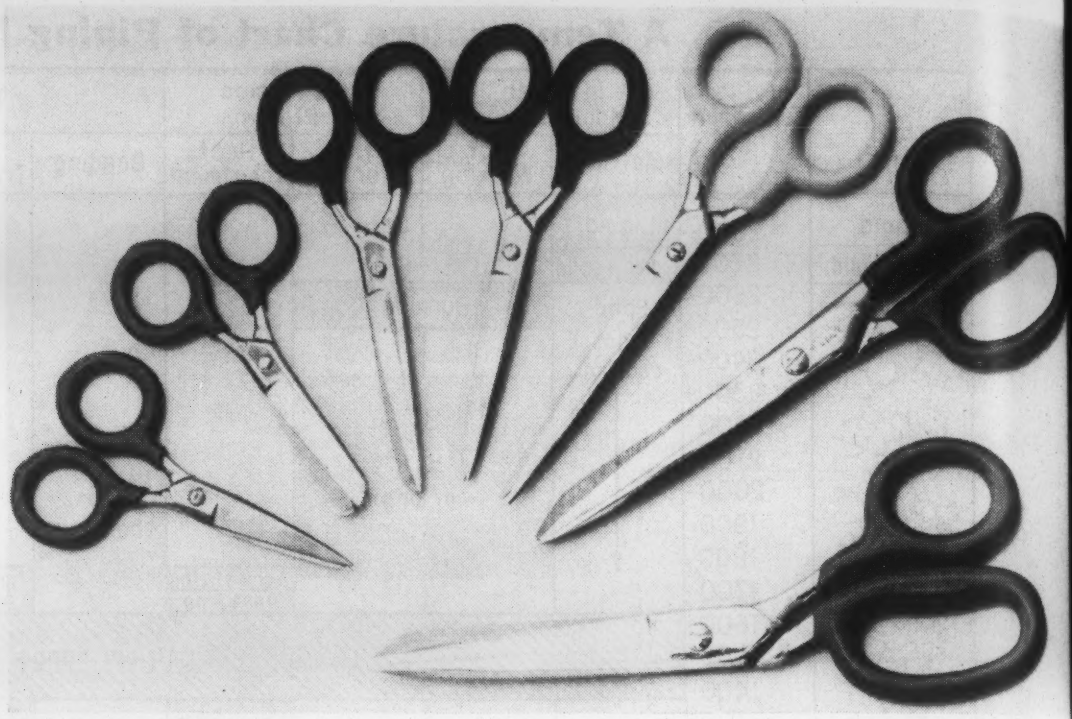
Based on a paper presented at the joint session of the Power and Metals Engineering Divisions at the Nov '56 annual meeting of the American Society of Mechanical Engineers in New York.

A Temperature Chart of Piping Materials





Chemically inert vinyl resins are widely used in . . . .



Dispersion coatings

Scissor handles are protected by thick vinyl plastisol or organosol coatings, which are usually applied by dipping.

Vinyl Coatings for Metal Products

by **R. A. Calsibet,** *Bakelite Co.*

■ Vinyl resins possess a unique combination of properties that makes them particularly valuable for use in protective coatings. Because the resins are odorless and tasteless and have a low order of toxicity, they are extremely useful as sanitary coatings. Chemically, they are extremely inert: they are not attacked at room temperatures by inorganic acids and alkalies; they are insoluble in oils, greases, aliphatic hydrocarbons and alcohols; and they are resistant to water and aqueous salt solutions. Because of their toughness, flexibility and good adhesion, vinyl coatings can be applied to many metal parts before they are fabricated.

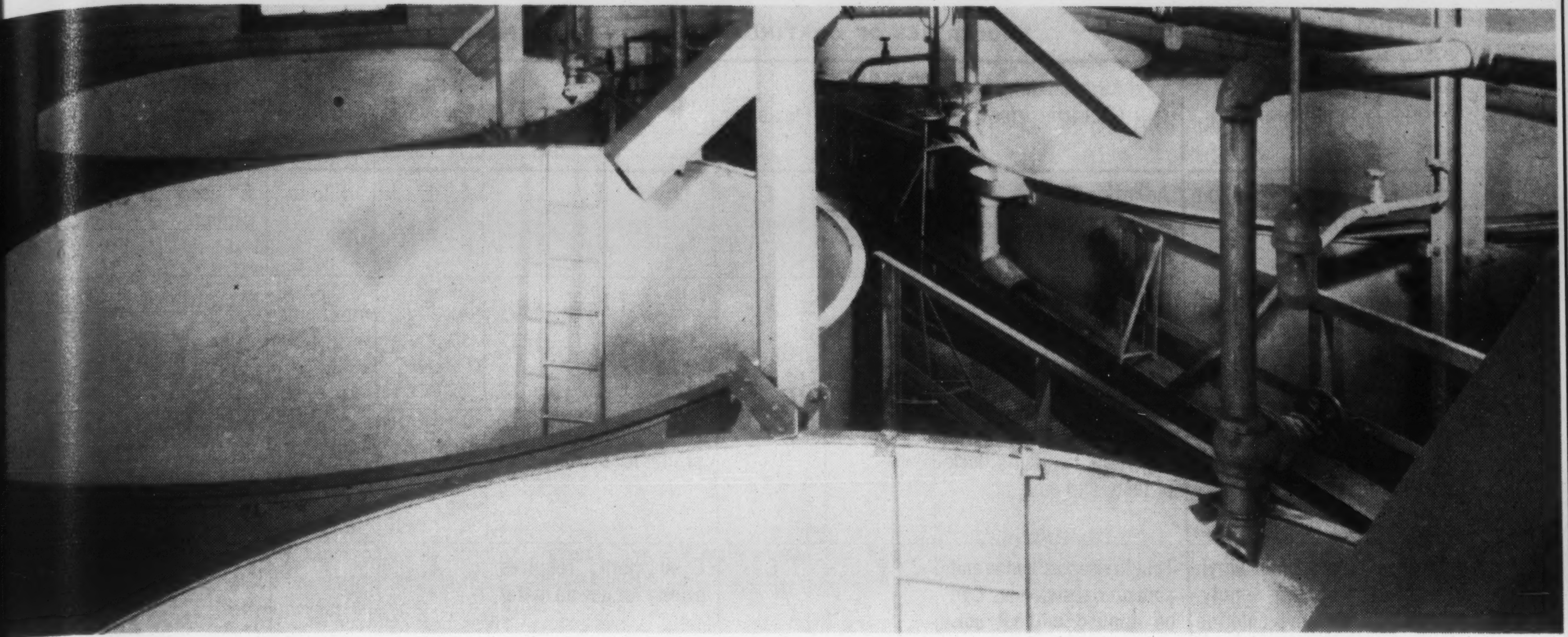
In general, vinyl coatings intended for metal surfaces can be divided into three broad categories: wash primers, solution coatings and dispersion coatings.

Wash primers

Properties—Wash primers based on vinyl butyral resins provide both an excellent anticorrosive metal pretreatment and a good adhesive bond for subsequent paint films. Primers that have excellent adhesion to such metal surfaces as steel, iron, chromium, cadmium, aluminum and magnesium can be formulated. In turn, excellent adherence to wash primers is exhibited by phenolic, nitrocellulose and other properly formulated vinyl paints.

Wash primers are applied as thin coatings of between 0.3 and 0.5 mil and require merely air drying to establish a firm bond. The coatings are tough and flexible over a wide temperature range. Formulations with a high pigment content exhibit no undue loss of mechanical properties and possess excellent durability and color stability during outdoor exposure.

Formulation—Table 1 lists a typical wash primer formulation used on a wide variety of metal surfaces. The base grind and acid diluent of this formulation are prepared separately and are combined not more than 8 hr before application. Films applied from solutions aged more than 8 hr exhibit a gradual decline in adhesion. There are wash primer formulations for specific metals, however, that may be mixed and stored for a considerable length of time before use without resulting in any deterioration of the finished coatings.

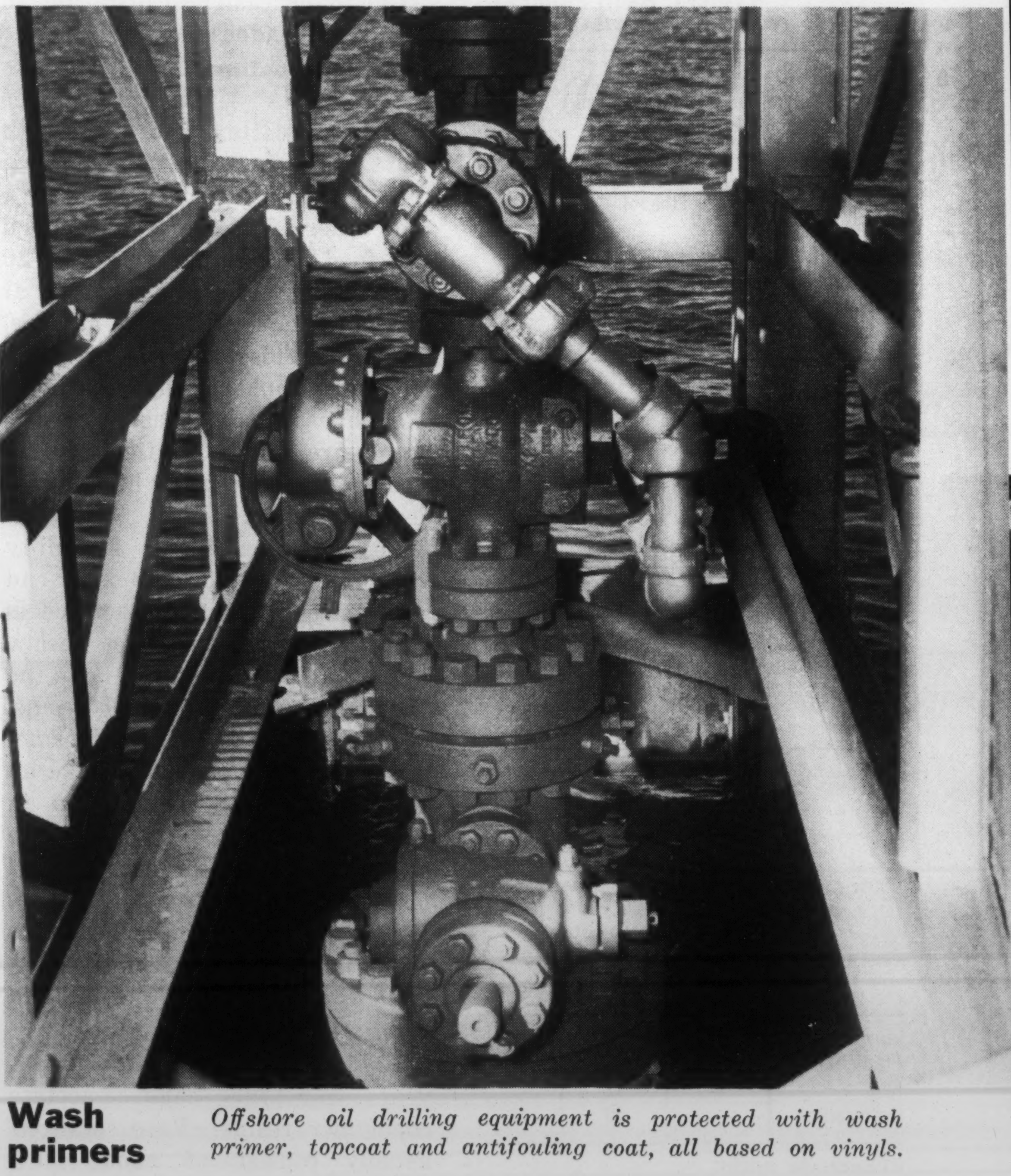


Solution coatings *Chemical processing tanks are often protected from corrosive liquids by solution coatings which are based on vinyl chloride-acetate resins.*

Application—Wash primers can be applied by spray, dip, brush or roller. It is essential that they be applied at high fluidity in order to fully cover the surface and to obtain the thin film required. Surfaces must be clean; blasting with grit or sand has proved more effective than wire brushing or flame descaling. Because wash primers dry entirely by solvent evaporation, top coats can be applied after as little as 15 min of air drying.

Uses—Vinyl wash primers are intended primarily to protect surfaces against corrosion and to prepare them for topcoats. They are not intended as complete finishing systems. Although they are widely employed for maintenance of marine equipment, wash primers have also been effectively used to protect original equipment.

For example, air conditioning equipment, particularly the easily corroded fan blades, is often protected with a wash primer. Aluminum aircraft surfaces, galvanized iron surfaces and outdoor signs are frequently given a vinyl wash primer to improve the adhesion of topcoats. Aluminum foil treated with wash primer has



Wash primers *Offshore oil drilling equipment is protected with wash primer, topcoat and antifouling coat, all based on vinyls.*

PROPERTIES OF COATINGS BASED ON VINYL RESINS[a]

Type of Coating	Outstanding Characteristics	Abrasion Resistance	Flexibility	Adhesion	Film Toughness	Hardness	Weather Resistance	Water Resistance (hot/cold)
Wash Primer (based on vinyl butyral)	Adhesion	—	E	E	E	F to G	E used as primer	F/F
Solution (based on vinyl chloride-acetate copolymers)	Color retention, chemical resistance, lack of taste and odor	E	E	F to G	E	F	E pigmented	G/E
Organosol (based on vinyl chloride-acetate copolymers)	High solids content, color retention, flexibility, lack of taste and odor	E	E	E to cloth; requires primer for use on metal	E	F	E pigmented	E
Plastisol (based on vinyl chloride-acetate copolymers and vinyl chloride resins)	Toughness, resilience and abrasion resistance. Can be applied without solvents	E	E	E to cloth; requires primer for use on metal	E	F	E pigmented	Softens/G

[a] E—excellent, G—good, F—fair, P—poor.

TABLE 1—TYPICAL WASH PRIMER[a] (WP-1, MIL-C-15328A)

BASE GRIND[b]	
Vinyl Butyral Resin (Bakelite XYHL)	7.2
Zinc Chromate Pigment	6.9
Talc	1.1
Lampblack	Trace
Isopropanol, 99%, or Ethanol	48.7
Butyl Alcohol	16.1
ACID DILUENT	
Phosphoric Acid, 88%	3.6
Water	3.2
Isopropanol, 99%, or Ethanol	13.2

[a] Percents by weight.
[b] Base grind and diluent are prepared separately and mixed before application.

TABLE 2—TYPICAL AIR DRY VINYL SOLUTION PRIMER[a]

Vinyl Resin VMCH[b]	8.0
Vinyl Resin VYHH[b]	8.0
Titanium Dioxide Pigment	12.0
Tricresyl Phosphate Plasticizer	3.0
Methyl Isobutyl Ketone and Toluene (50:50)	69.0

[a] Percents by weight.
[b] Bakelite Co.

TABLE 3—COMPARISON OF PLASTISOL, ORGANOSOL AND SOLUTION FORMULATIONS[a]

	Plastisol	Organosol	Solution
Vinyl Resin	60	35	12
Plasticizer	40	13	2
Ketone	—	12	43
Hydrocarbon	—	40	43

[a] Percents by weight.

been found easier to print and to bond with adhesives.

Solution coatings

Properties — Vinyl copolymer solution coatings form smooth surfaces, are neutral and nonoxidizing, and are characterized by a low order of odor and taste. Used in food packaging for over 20 years, they are not attacked at normal temperatures by alkalies, mineral acids, alcohols, greases, oils or aliphatic hydrocarbons. Toughness and abrasion resistance are high, particularly in coatings utilizing the higher molecular weight resins. The coatings have excellent flexibility down to −65 F. At the other end of the scale, however, service is limited to temperatures below about 160 F because of the thermoplasticity of vinyl resins.

Formulation — Vinyl chloride-vinyl acetate copolymers make up the bulk of the resins used in vinyl solution coatings. These copolymers run high in vinyl chloride content (87% and up), the exact proportion of chloride to acetate being carefully controlled to produce the desired end properties.

Ketones are the primary solvents for the chloride-acetate copolymer resins. Base solutions usually consist of about 20% solids when a standard resin (VYHH) is used. Lower solids contents are used with the higher molecular weight, less soluble grades of resins.

Plasticizers are incorporated in most vinyl coatings to increase flexibility, or to allow better solvent release. When used correctly they have little or no effect on chemical resistance of the film.

A wide choice of pigments is available for vinyl solution coatings. Zinc and natural iron pigments should be avoided because they tend to promote degradation of the film by heat or light. Since pigments or fillers usually do not provide any reinforcing action in the film, only enough pigment is added to provide ultraviolet opacity and light stability.

A typical air drying vinyl solution primer for metal surfaces is listed in Table 2. Use of a modified vinyl resin (VMCH) containing about 1% of maleic acid groups gives this formulation excellent adhesion to smooth surfaces. Another modified solution resin containing about 6% vinyl alcohol groups (VAGH) is available. This is the only air drying resin that adheres to wash primers. Air dried films based on unmodified vinyl chloride-acetate resins (VYHH) can be stripped

Solvent Resistance	Acid Resistance	Alkali Resistance	Color Retention	Gloss Retention (after exterior) exposure)
Softens but does not lose adhesion	P	P	E	Not normally used where gloss is a factor
P—ketones and esters; E—alcohols and aliphatics; swells with aromatics	E—inorganic; P—acetic, formic and lower organic acids	E, except ammonium hydroxide	E pigmented	E
P—ketones and esters; E—alcohols and aliphatics; swells with aromatics	E—inorganic; P—acetic, formic and lower organic acids	E, except ammonium hydroxide	E pigmented	G
P—ketones and esters; E—alcohols and aliphatics; swells with aromatics	E—inorganic; P—acetic, formic and lower organic acids	E, except ammonium hydroxide	E pigmented	F to G

from metal surfaces and are useful as temporary protection for articles in storage or transit.

Application — Vinyl solution coatings are frequently applied by spraying. Coatings can also be applied by rolling, dipping or knife-coating. To prevent cobwebbing during spraying, the solution must be thinned to about 12% resin solids. Because of the resulting low viscosity, thickness of the coating that can be applied is limited, although it is comparable to that obtained with nitrocellulose lacquers.

Baked coatings are usually cured for ½ hr at 250 to 350 F, depending on the formulation used and the surface coated. Air dry coatings usually dry to touch in about 15 to 20 min, but a small amount of solvent is retained for much longer periods.

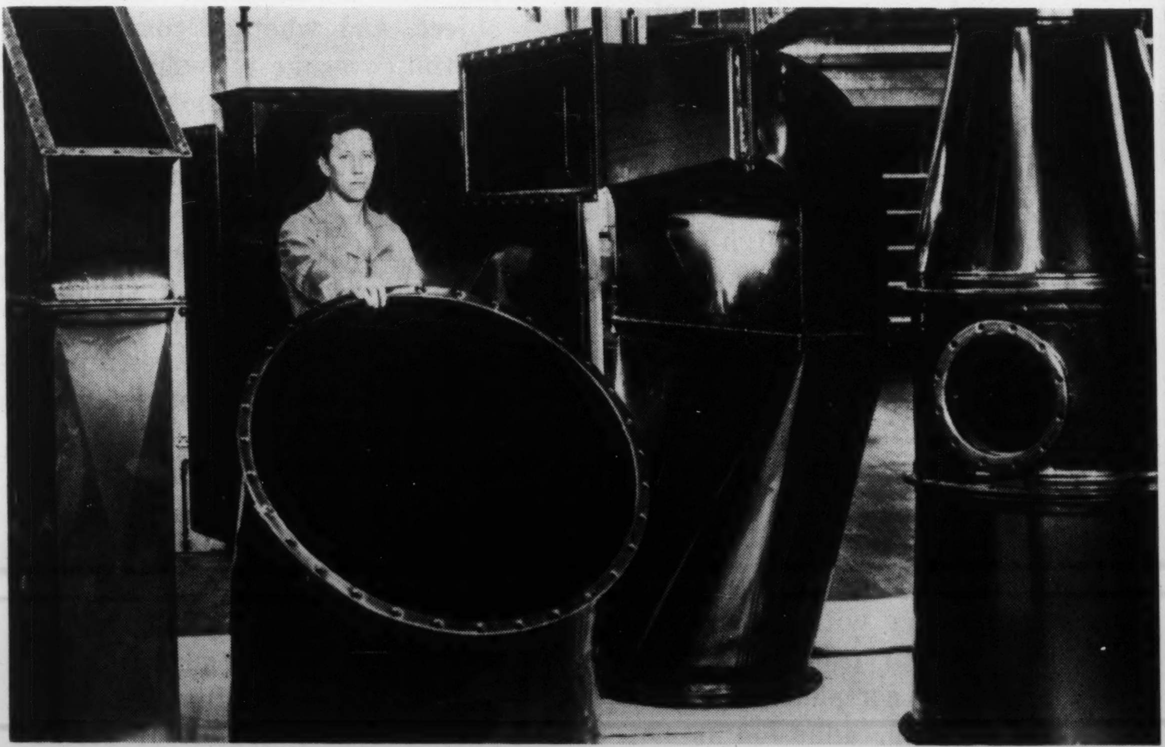
Uses—Vinyl copolymer solution coatings are rather costly compared to other commercial coatings. The special properties of vinyl coatings, however, make them economically feasible for a number of applications. A principal application has been for the interior lining of beer and soft drink cans. Baking (at 300 F) a vinyl solution coating over a phenolic or epoxy resin base primer produces a tough, flexible coating which completely protects the liquid content.

Such diverse items as metal cabinets, toothpaste tubes, bottle caps, time clocks, and industrial wash stands and showers have been protected from abrasion and corrosion by these coatings. Milking machines, separators and other dairy equipment exposed to severe cleaning solutions, lactic acid and abrasion, have also been successfully coated. On radar, electronic and television equipment, air drying coatings are frequently used to prevent damage to delicate components that might occur in baking. Solution coatings are also regularly used as top coats over wash primers to protect equipment exposed to salt or fresh water.

Dispersion coatings

Vinyl dispersions are finely divided suspensions of resin particles in organic media. Their principal advantage over solution coatings is that they have a much greater resin solids content at application viscosity. Vinyl dispersions are divided into two groups: plastisols and organosols. A plastisol is a nonvolatile suspension of finely divided resin particles in a plasticizer with stabilizers and pigments added. An organosol is similar to a plastisol except that the formulation contains a volatile diluent or a mixture of dispersant and diluent.

Properties — Plastisol and organosol coatings are tough, resilient, nonporous and resistant to abrasion and oxidation. These properties are retained down to −65 F. Vinyl dispersion coatings are exceptionally resistant to alcohols, mineral acids, strong alkalies, oxidizing agents, inorganic salts, aliphatic hydrocarbons, greases, oils and moisture at



Hoods and ducts *have vinyl plastisol coating for protection from corrosive liquids and fumes.*

continuous temperatures up to 160 F. They should not be exposed, however, to ketones, esters, or chlorinated or aromatic hydrocarbons.

Organosols and plastisols differ in a number of respects. Organosols form harder coatings because they generally contain a smaller proportion of plasticizer. The maximum thickness that can be applied in a single operation is limited to about 10 mils.

Plastisols, in contrast, form softer and glossier, rubberlike coatings on metal surfaces. Cured films as thick as 1/4 in. or more can be obtained in one application. The thickness of the plastisol coating provides a high degree of protection to metal surfaces; however, because of the adulterating effect of large amounts of plasticizers, plastisols have poorer properties than organosols on a mil-for-mil basis.

Formulation—The advantage of dispersion formulations over conventional coatings is evident from Table 3. Since they contain little or no solvents, dispersion formulations can utilize resins with a higher vinyl chloride content and higher molecular weight; these resins have increased abrasion and chemical resistance. The high solids content and low viscosity of the dispersion formulations also promotes economical application of moderately thick coats.

The same general classes of pigments can be used in dispersions as in other vinyl chloride type formulations. However, you should not use high-absorption pigments which would soak up the plasticizer and affect the viscosity of the formulation. Zinc and iron pigments should be avoided.

Application — A number of primers provide good adhesion of vinyl dispersion coatings to smooth metal surfaces. In many applications adhesion is quite satisfactory without a primer. In some small products where the article is completely enclosed by the coating, adhesion is not too important.

Although other methods can be used, organosols are generally applied by spraying. Solids contents of 60% and higher are common.

About This Series

This is the fourth in a series of five articles on synthetic resin-base coatings for metal products. Previous articles were devoted to acrylic (Dec '56), phenolic (Jan '57) and silicone (Feb '57) coatings. The last article in the series will cover the epoxies.

Several methods are available for applying plastisols. Of these, dip coating has been found very convenient. Coating thickness can be closely adjusted by preheating the metal before immersion (the more heat, the thicker the film) and by controlling viscosity of the formulation. The coating is partially cured by the heat from the base metal and is fully cured by subsequent baking.

Plastisol coatings can also be applied by conventional spraying techniques, including electrostatic spraying. Although they can be applied without diluents, plastisols are often converted to organosols by adding a nominal amount of volatile diluent. The choice between spray or dip application is generally governed by the type of equipment available, the size or shape of the metal object, and whether complete or partial coverage is required.

Plastisol and organosol coatings must be baked after application. Most bake schedules call for temperatures of 350 to 400 F for short time periods—usually 10 to 30 min. Ordinarily, a chemical reaction is not involved. The plasticizer solvates the resin particles and a continuous film is formed upon cooling.

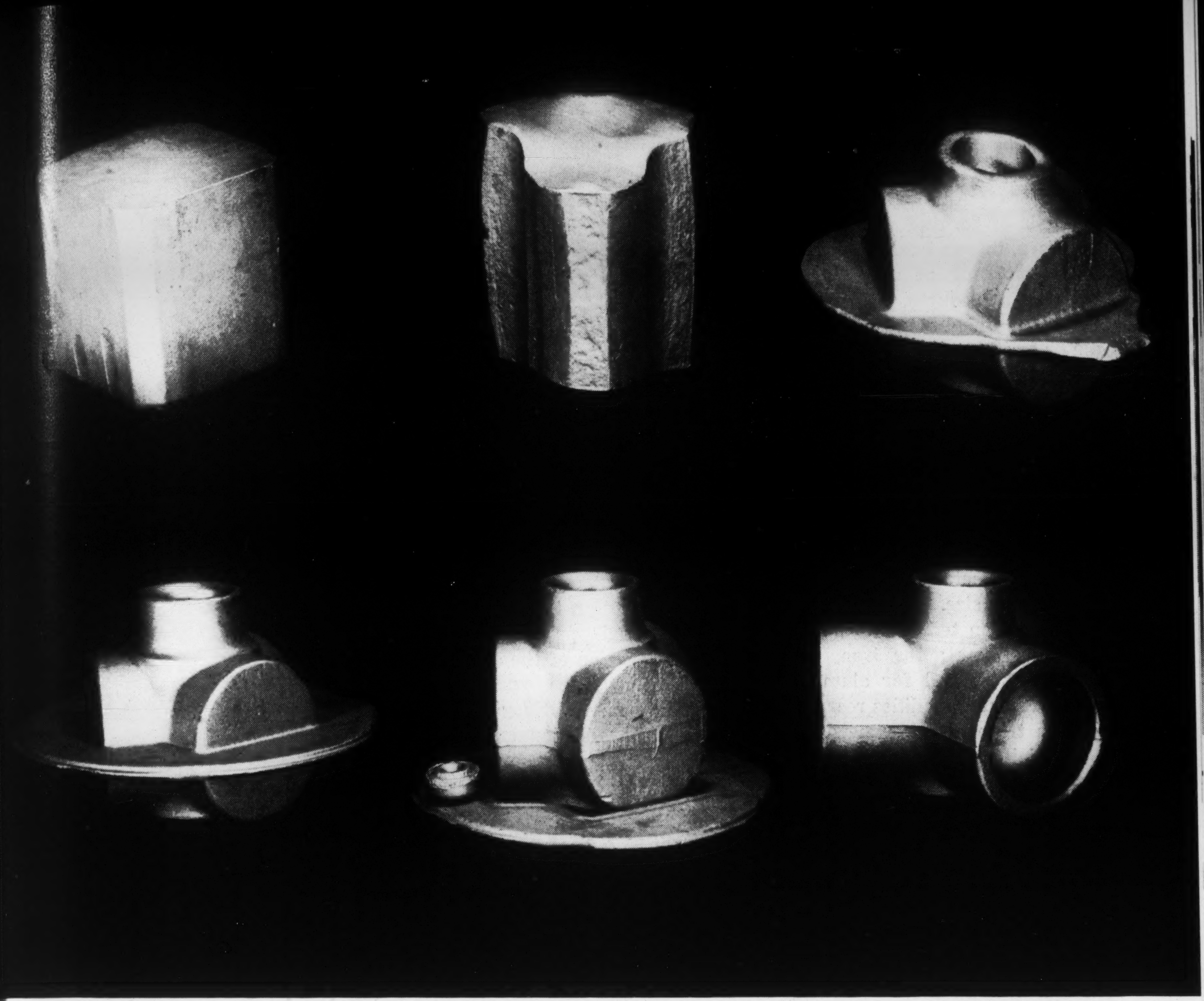
Unless special techniques are employed, dispersion coatings usually possess a flat finish. An exceptionally smooth finish can be obtained by buffing a partially fused organosol or plastisol surface, then completing the bake. One sprayable organosol formulation gives a decorative, textured surface when cured. In another process, vinyl coated sheet is formed and embossed in a wide variety of patterns subsequent to baking.

Cost—The materials cost of dispersion formulations is lower than that of solution formulations. Cost of resins for dispersion grades ranges from 28 to 30¢ per lb as compared to 32 to 55¢ for solution grades. Solution formulations also require a larger proportion of strong solvents.

Uses—Textured organosol coatings have been spray applied to the upper instrument panels and back panels of fold-down seats of sedans and station wagons. The material has a leather grain appearance and high abrasion resistance, and is reported to be less expensive than a corresponding alkyd finish.

Embossed plastisol coatings are widely used on such items as radio cabinets, air conditioners, file cabinets, and automobile dashboards and kick plates. Some of the more popular commercial applications of plain plastisol coatings include: office equipment, lawn furniture, refrigerator shelving, cable, wire harnesses, anchors, battery boxes, and interiors of vending, dishwashing and laundry machines. Plastisol coatings for business machines, decorative panels, luggage and typewriters are also planned.

Some of the more popular industrial applications of plastisols include: duct work, laboratory equipment, assembly fixtures, bus bars, impellers and drum interiors. The sound-deadening characteristics of plastisols are used to reduce the noise level of large conveyor rolls. Large tanks that must contain corrosive plating solutions are sprayed with plastisols and then baked in over-sized ovens. Steel racks and carrying hooks are often coated with plastisols to prevent marring of highly polished or finished parts. The coatings have also been successfully used on chemical processing equipment such as exhaust stacks, pipe sections, blowers and strainers.



Wyman-Gordon Co.

Six steps *in forging an aircraft propeller hub of 4340 steel.*

Hot Forged Parts

Forged parts are widely used in industrial applications. They range in weight from a fraction of an ounce to many hundred tons, and they are made from a great variety of metals and alloys. This 20-page report shows how forgings are used and gives the information you need to select the right material and the right forging method.

by John L. Everhart, *Technical Editor, Materials & Methods*

MATERIALS & METHODS MANUAL NO. 136—MARCH 1957

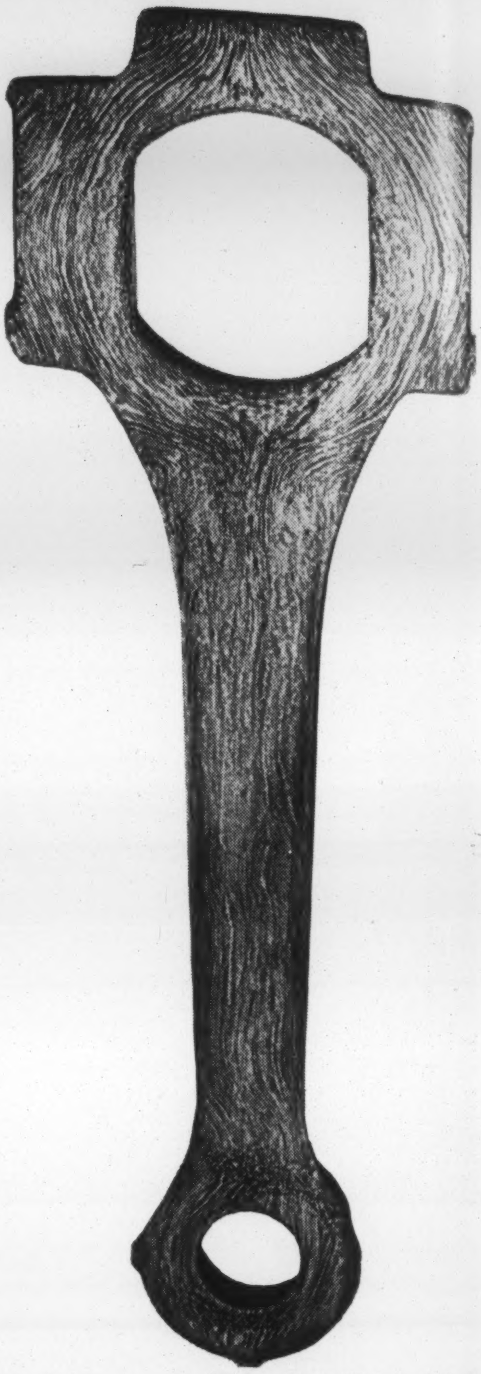
■ Forging is the shaping of metal by plastic deformation resulting from hammering or squeezing operations. Although there are methods of forging at room temperature, this manual is restricted to the shaping of metal by hot working procedures. Hot forging can be classified broadly into open die or smith forging and closed or impression die forging. Closed die forging can be subdivided into drop and steam hammer forging, press forging and upset forging.

The term "hot forging" means working above the recrystallization temperature of the metal. In this range, deformation does not harden the metal but does reduce the grain size. Minimum recrystallization temperature varies with the metal; for iron, it is about 840 F, and for aluminum 300 F. Alloying modifies recrystallization temperature somewhat.

Plasticity of a metal increases with temperature, and therefore less force is required to shape a metal as temperature increases. However, working temperatures must be limited because certain undesirable effects accompany increases in temperature. For example, scaling of steel may be excessive at high temperatures. Scale is undesirable because it can be worked into the surface and/or increase wear of the dies. Grain growth also increases with temperature. If the contour of the part permits, formation of extremely large grains can be prevented by finishing at a low temperature. Correct heating implies selecting a forging temperature range that assures the maximum plasticity consistent with minimum scaling, grain growth and surface roughness.

Forgings are produced from blooms or billets which have been rolled from the original cast ingot. During rolling, which for steel forging stock generally involves a reduction in cross-section area of at least one-third, directional properties are imparted to the structure, and soundness and uniformity of the material are improved. Because of directionality, strength and ductility of a rolled product are greater in the rolling direction than across it.

Directional properties result from elongation of the grains and certain impurities, such as sulfides, into fibers. Forging operations cause additional elongation and distortion of these grains and fibers, as shown in an accompanying illustration. This so-called "fibering" is an important characteristic of forgings, particularly those to be used under dynamic stresses, and metal flow should be controlled to obtain the greatest strength in the most important direction. Purchasers often specify the direction of fiber flow lines, particularly for parts that are to be subjected to high stresses in service. Because of these directional properties, together with grain refinement and elimination of porosity, forgings usually have better mechanical properties than castings of the same composition.



Drop Forging Assn.

Grain flow *in this connecting rod forging is revealed by etching. Fiber structure is retained regardless of subsequent heat treatment.*

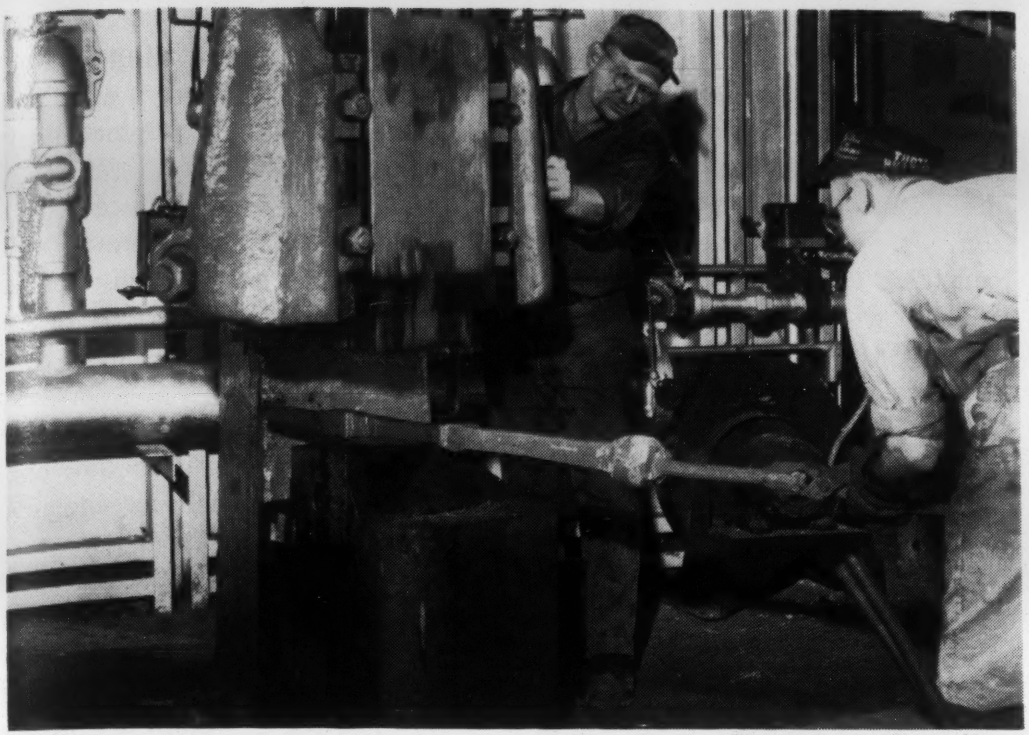
Open Die Forgings

Open die forgings are generally defined as those made between two flat dies, but in practice also include those made between dies which may be V-shaped, half round or half oval. The term applies also to forgings produced between swages that are struck by the dies.

Open die forging was the original forging method and requires the simplest equipment. The blacksmith forged parts on an anvil using various shaped hand tools. Modern open die forging employs mechanical hammers or presses. Open die forging is a skilled operation in which the operator controls the amount of reduction taken under each blow of the hammer, decides the pressure required and determines when the part being worked requires reheating.

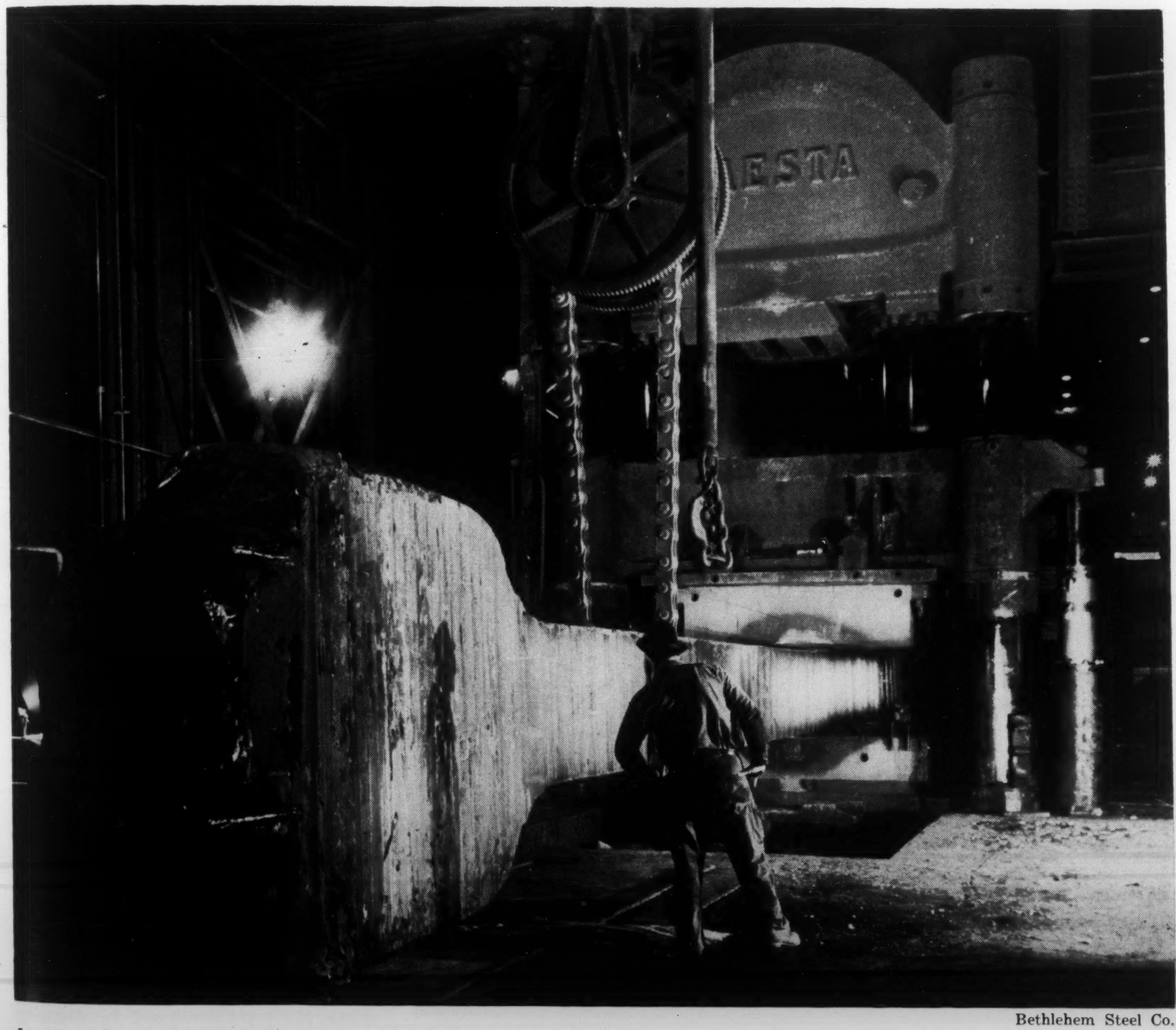
Since each part must be heated several times and shaped individually, frequently by repeated blows, the production rate is low; in general, the process is used to make a limited number of pieces. On the other hand, open die forging has the advantage of simplicity of tooling. It is also applicable to a much wider range of sizes than closed die forging; parts ranging from a few ounces to hundreds of tons in weight are made. Smaller parts are produced either on drop hammers or

Open die forgings vary greatly in size



Westinghouse Electric Corp.

Small *open die forgings can be produced on either hammers or presses.*



Bethlehem Steel Co.

Large *open die forgings like this 110-ft section of a press column are always made in presses.*

presses, but large parts such as airframe sections are always produced by squeezing in presses.

The processes

Common operations used in producing open die forgings follow:

Drawing out, by simultaneously reducing the cross section and elongating the ingot or bloom, produces a forging having a length considerably greater than its diameter. Ductility is greater in the longitudinal direction than in the transverse direction. Shafting is a typical product.

Upsetting reduces the length and increases the cross section of a forging. Typical parts are gear blanks, flanges and heavy sections in rotor forgings.

Piercing and punching form a cavity by forcing a punch into the steel. In open die forging terminology, piercing generally implies making a blind cavity by displacement without actual removal of metal. On small parts, this operation is often called cupping. Punching describes the same operation when the hole extends through the section and a solid punch is used to displace and remove metal in the form of a plug. In trepanning, a hollow punch is used, usually to produce a concentric cavity along the longitudinal axis.

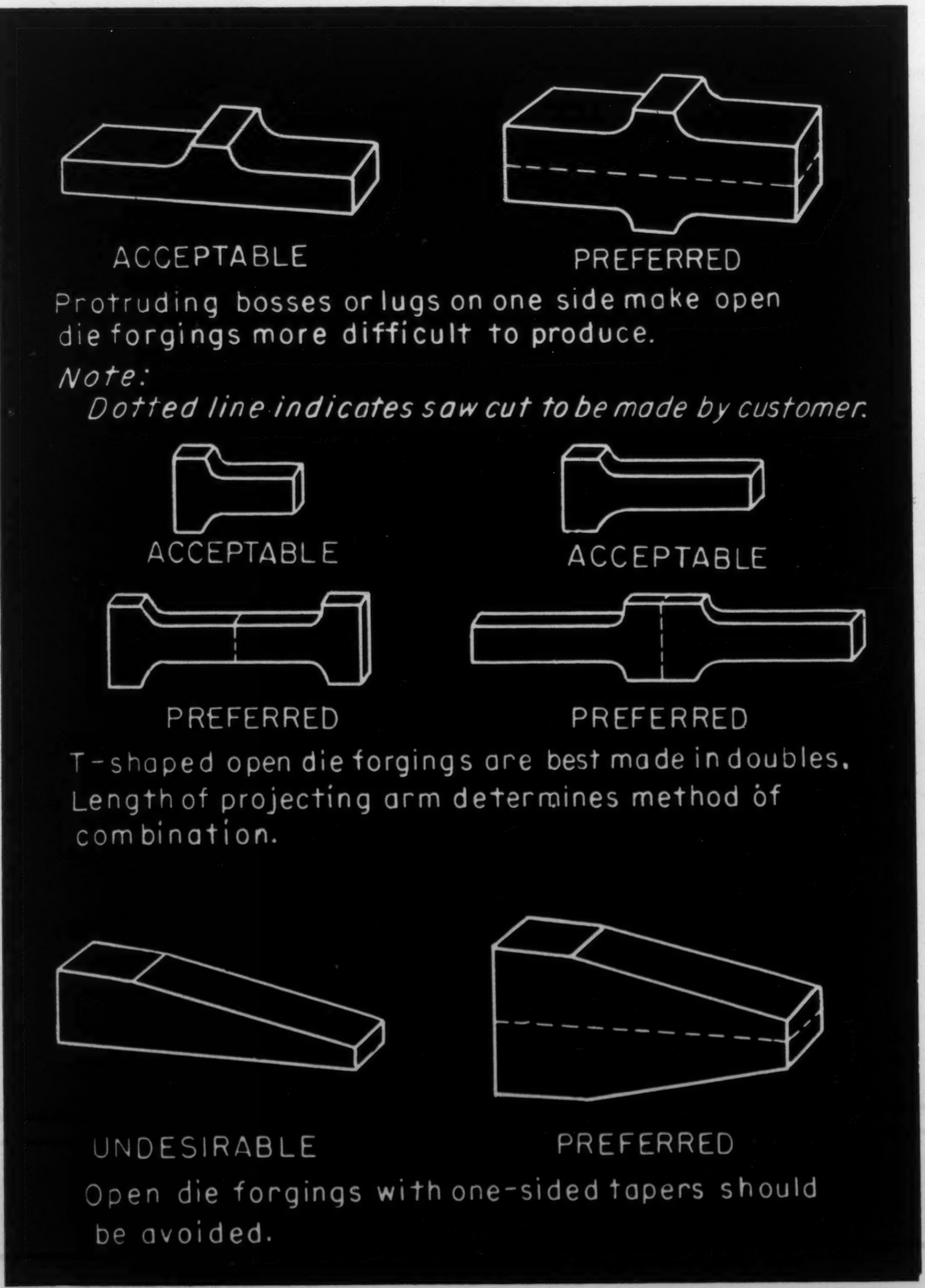
Drawing increases the length or reduces the wall thickness of a pierced or punched forging. The heated, pierced slug is forced over a mandrel through ring dies or rollers. High explosive shell and other ordnance equipment are made by drawing.

Hollow forging produces circular hollow parts by expanding on an enlarging bar or lengthening on a mandrel. Typical parts are chemical retorts, rings, gear tires and boiler drums.

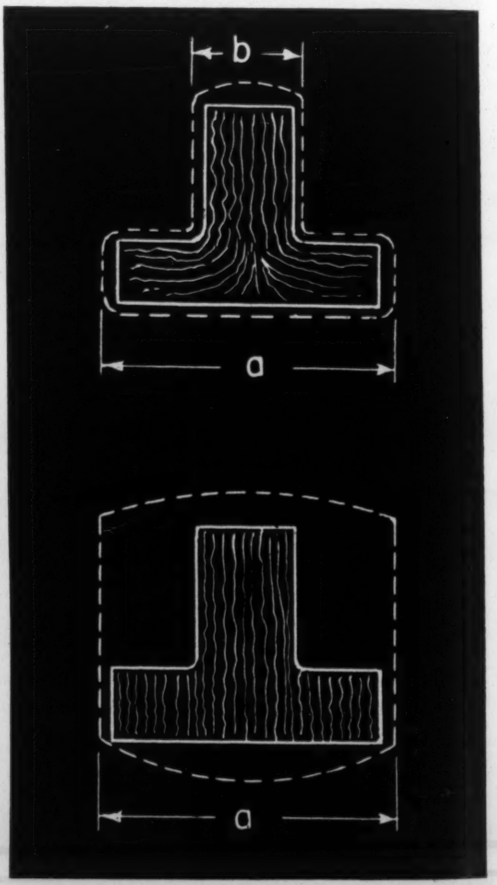
Closing in is used to produce a nozzle on the ends of hollow one-piece forgings such as chemical chambers and boiler drums.

Slabbing means making slabs or plate sections that are heavier or thicker than those that can be produced by rolling on a slabbing mill. Typical products are armor plate and vault plate.

In any of these forging methods, the amount of reduction affects the mechanical properties obtained in the part. Increasing the total reduction accentuates the effect of the particular forging


ACCEPTABLE
PREFERRED
Protruding bosses or lugs on one side make open die forgings more difficult to produce.
Note:
Dotted line indicates saw cut to be made by customer.
ACCEPTABLE
ACCEPTABLE
PREFERRED
PREFERRED
T-shaped open die forgings are best made in doubles. Length of projecting arm determines method of combination.
UNDESIRABLE
PREFERRED
Open die forgings with one-sided tapers should be avoided.

Design considerations *for open die forgings.* (Aluminum Co. of America)



Alternate methods *can be used to produce parts. Flow lines show that the part produced by drawing out to size* b *and upsetting (top) is stronger than the part produced by drawing out to size* a *and machining.*

method on the properties. As reduction increases in drawing out, for example, the tendency is for increasing ductility in the longitudinal direction and decreasing ductility in the tangential direction.

In many instances, there are several methods of producing an open die forging, some simpler than others and therefore lower in cost. Unless guided by specification, the forging producer will usually use the most economical method. Sometimes the method chosen will not produce a part with the properties required for a specific application. An accompanying sketch shows, in solid lines, the contour of a simple part which could be forged by two methods: 1) drawn out to size (a) over the length required and machined to size or 2) drawn out to size (b) and upset to form the head. The part produced by the second method has greater ductility than that produced by machining. It also has continuous flow lines conforming with the general forging contour as opposed to the discontinuous flow lines in the part produced by machining. The superiority of the second method over the first is particularly important for parts that will be heavily loaded in service or subjected to alternating stresses.

The above example shows why it is advisable for the customer to give the producer as much information as possible about test requirements and service conditions under which the forging will be used. Such information will enable the producer to select the method that gives optimum properties for the application.

Design

Shapes produced by open die forging are generally much simpler than those produced by the closed die process. Tolerances are considerably greater since there is little or no lateral confinement of the stock. Also, there is more variation from part to part than in closed die forging.

Shapes vary widely in complexity. Open die forgings are supplied to the customer "as forged" and the final shape is obtained by machining. Generally, the producer will prepare, from the drawing of the finished part, a sketch of a forging from which the part can be machined. Depending on the customer's demand, this forged shape can be simple or sufficiently elaborate to approach the shape of the final part quite closely. Complexity of the "as forged" part will determine the cost of the part, because forging time increases with the amount of manipulation required. However, complex designs may save sufficient metal and machining time to offset the cost of additional forging time.

Open die forging is facilitated by keeping bosses, lugs and tapers symmetrical, and by making small recesses and notches full. Holes generally must be drilled, unless they are large and located symmetrically in the part.

Sometimes better forged properties are obtained by forging in multiples and sawing to obtain the desired part. Parts having lugs on one side are difficult to forge, and improved results are obtained by producing a symmetrical double forging which is then sawed in half. Similarly, T-shaped forgings and forgings with tapers on one side are preferably made in doubles.

Commercial open die forgings are generally produced in small quantities, and trial and error methods of design are impractical. It is therefore necessary to consider carefully the factors that affect performance of a forged part; these include 1) stress concentrations, 2) surface finish, 3) section size or material strength, 4) deflection, 5) steady and alternating stresses, 6) grinding cracks, and 7) heat treatment.

Closed Die Forgings

Closed die forgings are produced by shaping hot plastic metal within closed dies. One advantage of closed die forging over open die forging lies in the lesser degree of skill required. It is easier to train a man for closed die forging because the dies are engineered to supply much of the control of shape, whereas in open die forging the hammer man must shape the piece with a minimum number of simple tools. Another advantage is production speed; much higher production rates are possible with the closed die process than with open dies. A third advantage is the ability to hold closer tolerances.

The processes

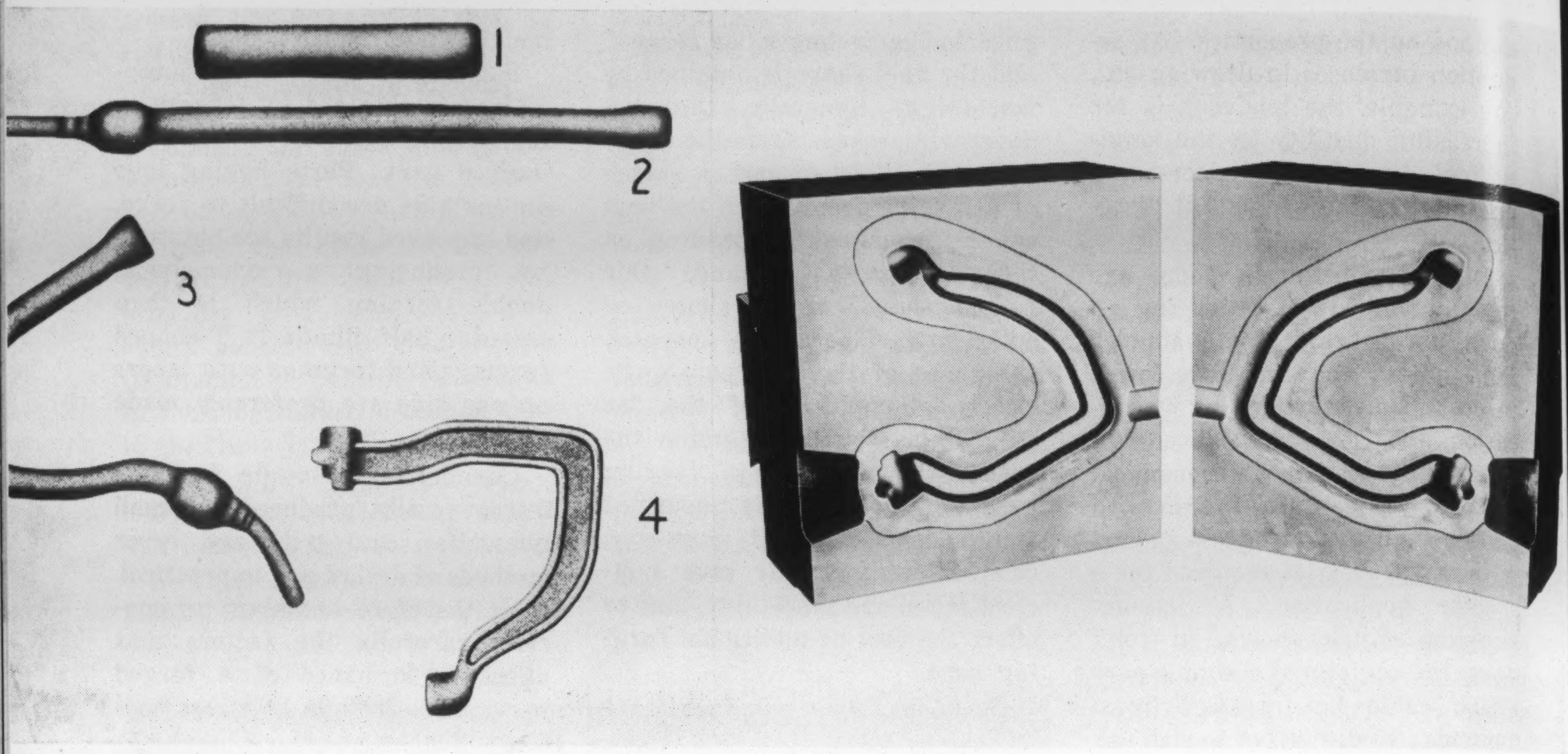
Closed die forgings are generally produced by drop or steam hammer forging, press forging or upset forging. These methods are suitable particularly for relatively long runs of duplicate parts, since amortization of the die cost is a considerable factor in the cost of production.

Drop and steam hammer forgings are produced by the action of a hammer which forces the hot plastic metal to flow into the die cavity by a series of impact blows. Most commercial closed die forgings are produced by this method.

The particular advantage of hammer forging is speed of operation. Rapid blows permit the stock to be worked in many cases without reheating, and a single die can be used to edge, block and finish the part. The "edger" forms the bar stock into a suitable shape to fill the die, the "blocker" forms a rough contour of the part, and the finishing cavity forms the part to its required shape and size. Flash formed during forging is removed with special trimming dies on a separate machine.

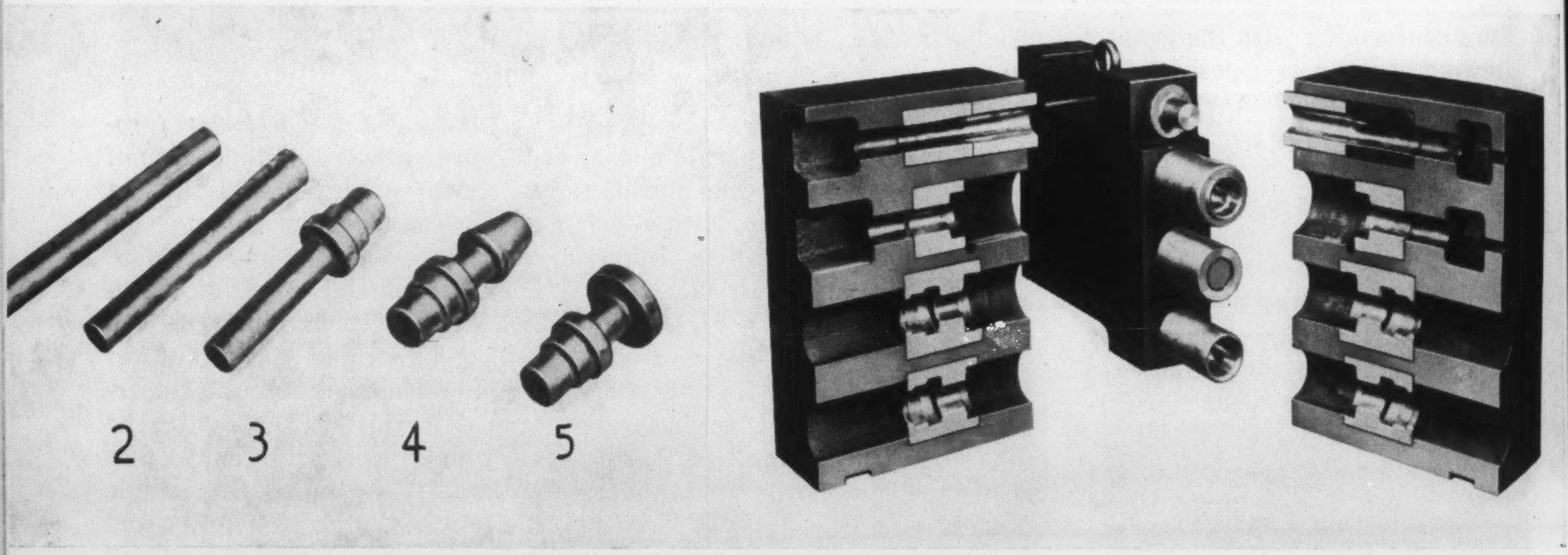
This method is used to produce forgings ranging from less than an ounce to several hundred pounds in weight.

Press forgings are essentially similar to drop forgings but are



Drop Forging Assn.

Stages in drop hammer forging *a riveter frame. Metal stock 2½ in. in dia and 14 in. long (1) is heated to the proper temperature. "Fullering" (2) reduces the cross section, elongates the stock to the proper length, and gathers the necessary metal at each end to form bosses. The fullered stock is bent (3) to conform to the impressions in the finishing dies (shown at right), placed in the die cavity and forged with several hammer blows. After trimming, the finished forging (4) requires only drilling of holes in the bosses to complete the part.*

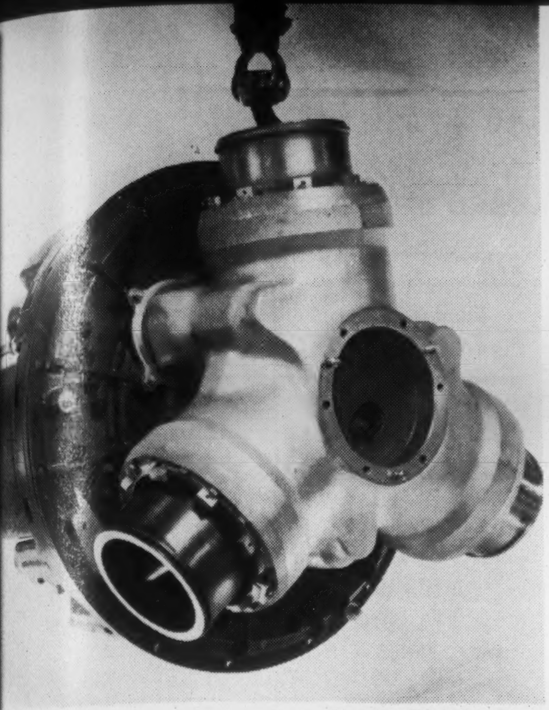


Drop Forging Assn.

Stages in upset forging *a cluster gear blank. A bar of stock (1) heated to the correct forging temperature is upset in the upper position of the dies to gather stock for one end of the gear (2). The smaller end of the cluster is finished (3) in the upper center position of the dies, the opposite end of the bar is upset (4) in the lower die position to gather stock, and the gear blank is finished (5) by upsetting and forming the large end in the lower center position of the dies. Four-cavity dies are shown at right.*

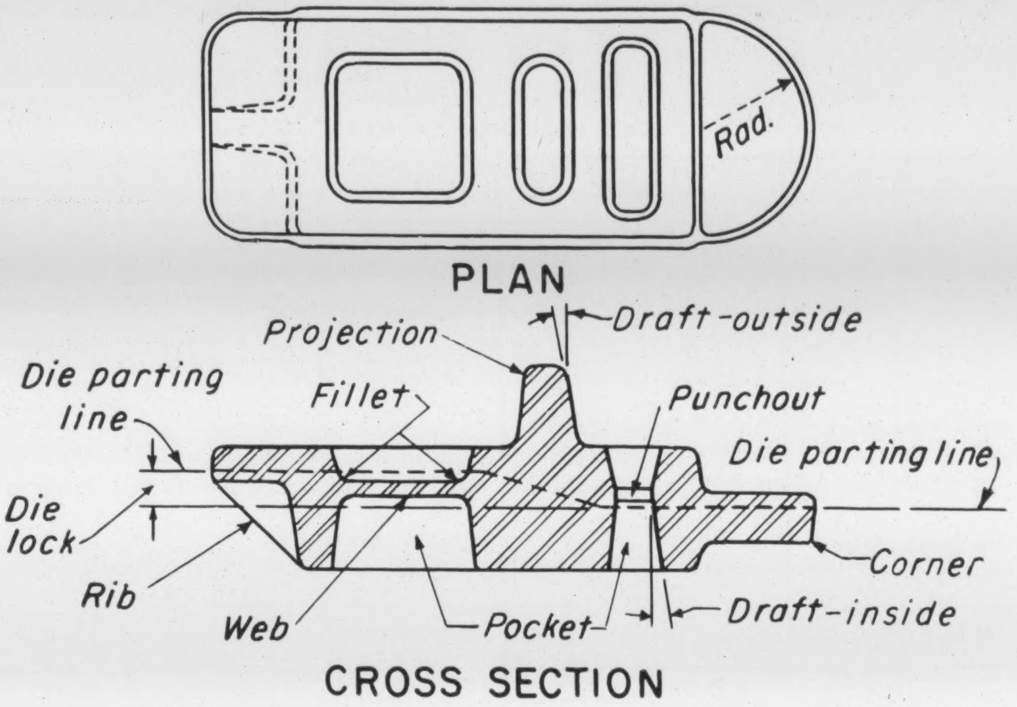
produced by squeezing in mechanical or hydraulic presses. This method is particularly adapted to parts that are quite symmetrical and that require only one or two operations. Frequently, small parts having irregular shapes can be produced in pairs or larger multiples to obtain the symmetry required for press forging with a minimum of preparatory steps (such as edging, blocking, etc.).

Press forging operating costs are lower than those of drop forging. Although die costs are about the same for both processes, die life for press forging is greater than for drop forging.

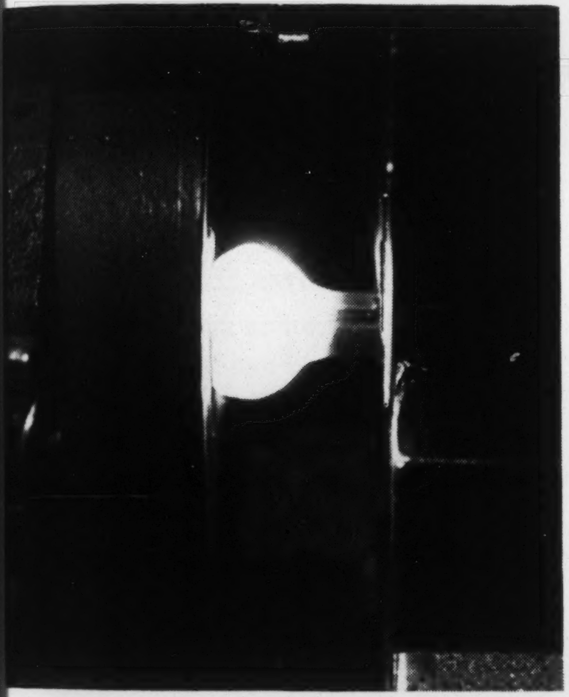


Curtiss-Wright Corp.

Propeller hub *produced by a recently developed precision die forging method that eliminates rough cross boring, profiling and several barrel forming operations that formerly preceded core hardening heat treatment. Based on a production of 100 hubs per month, the annual cost reduction is $79,500.*


Rad.
PLAN
Projection
Draft-outside
Die parting line
Fillet
Punchout
Die parting line
Die lock
Rib
Web
Pocket
Corner
Draft-inside
CROSS SECTION

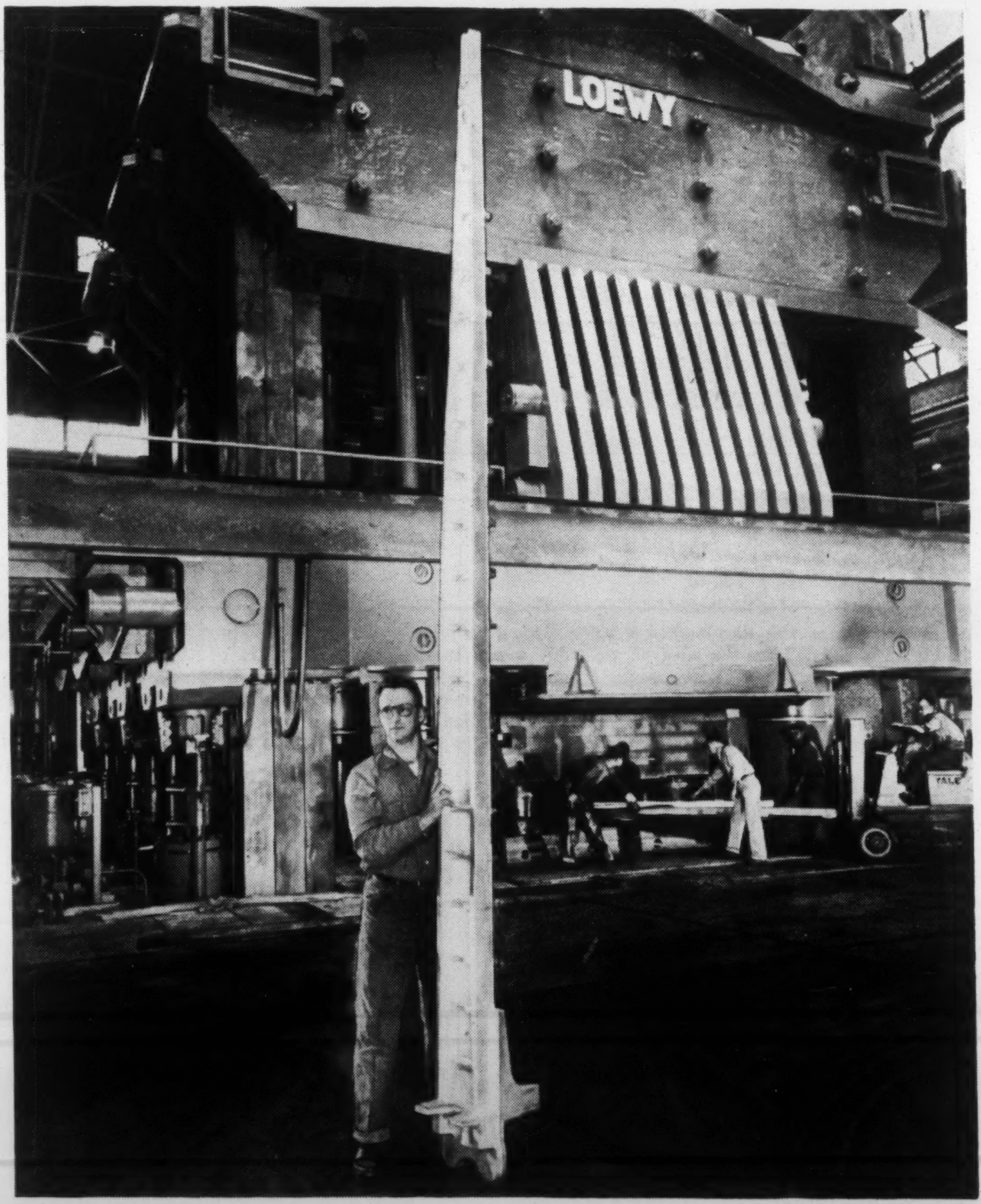
Forging terminology *that should be used in preparing drawings for parts to be forged is shown in plan and cross section views. This example requires a set of locked dies because the two pockets at left are separated by a web on a different plane from the parting line required for the right-hand portion of the part. It is preferable to keep the parting line in a single plane, if possible, to avoid the need for locked dies.* (Steel Improvement & Forge Co.)



International Nickel Co.

Upsetting *a bar gathers stock for further operations. The heated bar gripped in the holder at right is forced against the anvil at left which is also moving to left. Difference in speed between anvil and ram determines the amount of upset.*

Upset forgings are also produced by squeezing instead of by hammering. The dies not only form the impression but also grip the stock. Heated bar or rod stock is inserted between the movable



Wyman-Gordon Co.

Largest closed die forgings *have been made on this 50,000-ton press.*

STANDARD TOLERANCES FOR CLOSED DIE FORGINGS

SHRINKAGE AND DIE WEAR

Length or Width, in.	Shrinkage		Max Net Wt, lb	Die Wear	
	Commercial, in. + or −	Close, in. + or −		Commercial, in. + or −	Close, in. + or −
1	0.003	0.002	1	0.032	0.016
2	0.006	0.003	3	0.035	0.018
3	0.009	0.005	5	0.038	0.019
4	0.012	0.006	7	0.041	0.021
5	0.015	0.008	9	0.044	0.022
6	0.018	0.009	11	0.047	0.024
For each additional in. add	0.003	0.0015	For each additional 2 lb add	0.003	0.0015
For example:			For example:		
7	0.021	0.011	13	0.050	0.026
12	0.036	0.018	21	0.062	0.031

Shrinkage and die wear tolerances shall not be applied separately. They shall be applied as the sum of the two and shall be measured in such a way as to eliminate draft or variations in draft. They apply to that part of the forging formed by a single die block, and to no dimension crossing the parting plane.

DRAFT ANGLE

	Drop Forgings		Upset Forgings	
	Outside, deg	Inside Holes, deg	Outside, deg	Inside Holes, deg
Nominal angle	7	7 or 10	3	5
Commercial limits	0—10	0—13	0—5	0—8
Close limits	0—8	0—8	0—4	0—7

MISMATCHING

Net weight up to	Commercial, in.	Close, in.
1 lb	0.015	0.010
7 lb	0.018	0.012
13 lb	0.021	0.014
19 lb	0.024	0.016
For each additional 6 lb add	0.003	0.002
For example:		
37 lb	0.033	0.022
55 lb	0.042	0.028

Mismatching is the displacement of a point, in that part of a forging formed by one die block of a pair, from its desired position when located from the part of the forging formed in the other die block of the pair. Mismatching does not include any displacement caused by variation in thickness of the forging, but is only the displacement in a plane parallel to the main or fundamental parting plane of the dies.
Mismatching tolerances are independent of, and in addition to, any other tolerances.

QUANTITY

Number of Pieces on Order	Over-Run	Under-Run
	No. of Pieces	
1—2	1	0
3—5	2	1
6—19	3	1
20—29	4	2
30—39	5	2
40—49	6	3
50—59	7	3
60—69	8	4
70—79	9	4
80—99	10	5
	Percent	
100—199	10	5.0
200—299	9	4.5
300—599	8	4.0
600—1249	7	3.5
1250—2999	6	3.0
3000—9999	5	2.5
10,000—39,999	4	2.0
40,000—299,999	3	1.5
300,000 up	2	1.0

Quantity tolerances shall be the permissible over or under-run allowed for each release or part shipment of an order. Any shipping quantity within the limits of over and under-run shall be considered as completing the order. Commercial and close tolerances shall be the same amounts.

NOTES

Standard tolerances given on these pages are for forgings up to 100 lb.

Special tolerances may be specified when regular tolerances are not applicable. Regular tolerances, shown here, are classed as "Commercial Standard" and "Close Standard."

Source: Drop Forging Assn.

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and stationary dies with sufficient material projecting beyond the gripping portion of one of the dies to fill the cavity after upsetting is complete. A header ram then pushes the dies together and squeezes the end of the rod or bar into the desired form. It is possible to enlarge the cross section at areas other than the end of the bar by locating the cavity accordingly. Simple parts can be formed in one operation, but as many as five steps may be required to form a complicated shape. Forgings weighing from a few ounces to about 500 lb are produced by upsetting.

Upset forging is used to produce the following types of parts: 1) simple forgings made in a

THICKNESS

Max Net Wt	Commercial, in.		Close, in.	
	Minus	Plus	Minus	Plus
0.2	0.008	0.024	0.004	0.012
0.4	0.009	0.027	0.005	0.015
0.6	0.010	0.030	0.005	0.015
0.8	0.011	0.033	0.006	0.018
1.0	0.012	0.036	0.006	0.018
2.0	0.015	0.045	0.008	0.024
3.0	0.017	0.051	0.009	0.027
4.0	0.018	0.054	0.009	0.027
5.0	0.019	0.057	0.010	0.030
10.0	0.022	0.066	0.011	0.033
20.0	0.026	0.078	0.013	0.039
30.0	0.030	0.090	0.015	0.045
40.0	0.034	0.102	0.017	0.051
50.0	0.038	0.114	0.019	0.057
60.0	0.042	0.126	0.021	0.063
70.0	0.046	0.138	0.023	0.069
80.0	0.050	0.150	0.025	0.075
100.0	0.058	0.174	0.029	0.087

Thickness tolerances for drop hammer forgings apply to the over-all thickness measured in a direction perpendicular to the fundamental parting plane of the dies. For upset forgings, thickness tolerances apply to the metal actually enclosed and formed by the dies, measured parallel to the direction of travel of the ram.

FILLET AND CORNER

Max Net Weight	Commercial, in.	Close, in.
0.3 lb	3/32	3/64
1.0 lb	1/8	1/16
3.0 lb	5/32	5/64
10.0 lb	3/16	3/32
30.0 lb	7/32	7/64
100.0 lb	1/4	1/8

Fillet and corner tolerances apply to all intersection surfaces even though drawings or models indicate sharp corners. If such drawings or models have or indicate fillet or corner dimensions of larger radii than these standards, such larger dimensions shall be considered as actually specified and the tolerances shall be "special tolerances."

Where a corner tolerance applies on the meeting of two drafted surfaces, the tolerance shall apply to the narrow end of such meeting and the radius will increase toward the wide end. The total increase in the radius will equal the length of the drafted surface in inches multiplied by the tangent of the nominal draft angle.

single operation, such as rivets and grinding balls, 2) parts forged on the end of a bar in multiple operations, such as eye and tee bolts, 3) short shank parts forged in multiple operations, including gear blanks with hubs, 4) parts having holes forged in multiple operations, such as nuts, clutch rings and pipe couplings, 5) parts having deep recesses that do not pierce the part, including socket wrenches and drag links, and 6) tubing upset to increase wall thickness, such as line pipe and welding necks.

Design

Closed die forgings are produced in steel dies in which the shape of the part is sunk (hollowed out) to form the die impression. The dies must be designed to shape the part in the easiest possible manner, to control direction of flow of the metal, and to hold required tolerances. For a small part, a single die may contain all of the impressions required to perform preliminary forming, blocking and finishing operations. For a large part, however, several dies may be required. Die blocks are usually made from alloy steel that has been forged to provide uniform properties.

A fundamental aim in design is to divide the impression as equally as possible between the top and bottom dies in order to obtain the proper distribution of grain flow. It is desirable to keep the parting line (flash line between the dies) in one plane to facilitate trimming the flash. However, it is possible to part a forging in two or more planes if necessary for an unusual shape.

To permit removal of a forging from the die cavity, it is necessary to taper the vertical sides. Draft is generally specified as 7 deg on the outside and 10 deg on the inside. However, draft can be varied considerably. Depending on the material and the design of the part, draft angles of less than 1 deg and as high as 15 deg have been used.

Metal flow in forging operations generally changes direction at radii and fillets. Therefore, good design calls for large radii to promote the production of sound forgings. Sharp radii and fillets not only increase the chance of defective forgings but also cause excessive die wear.

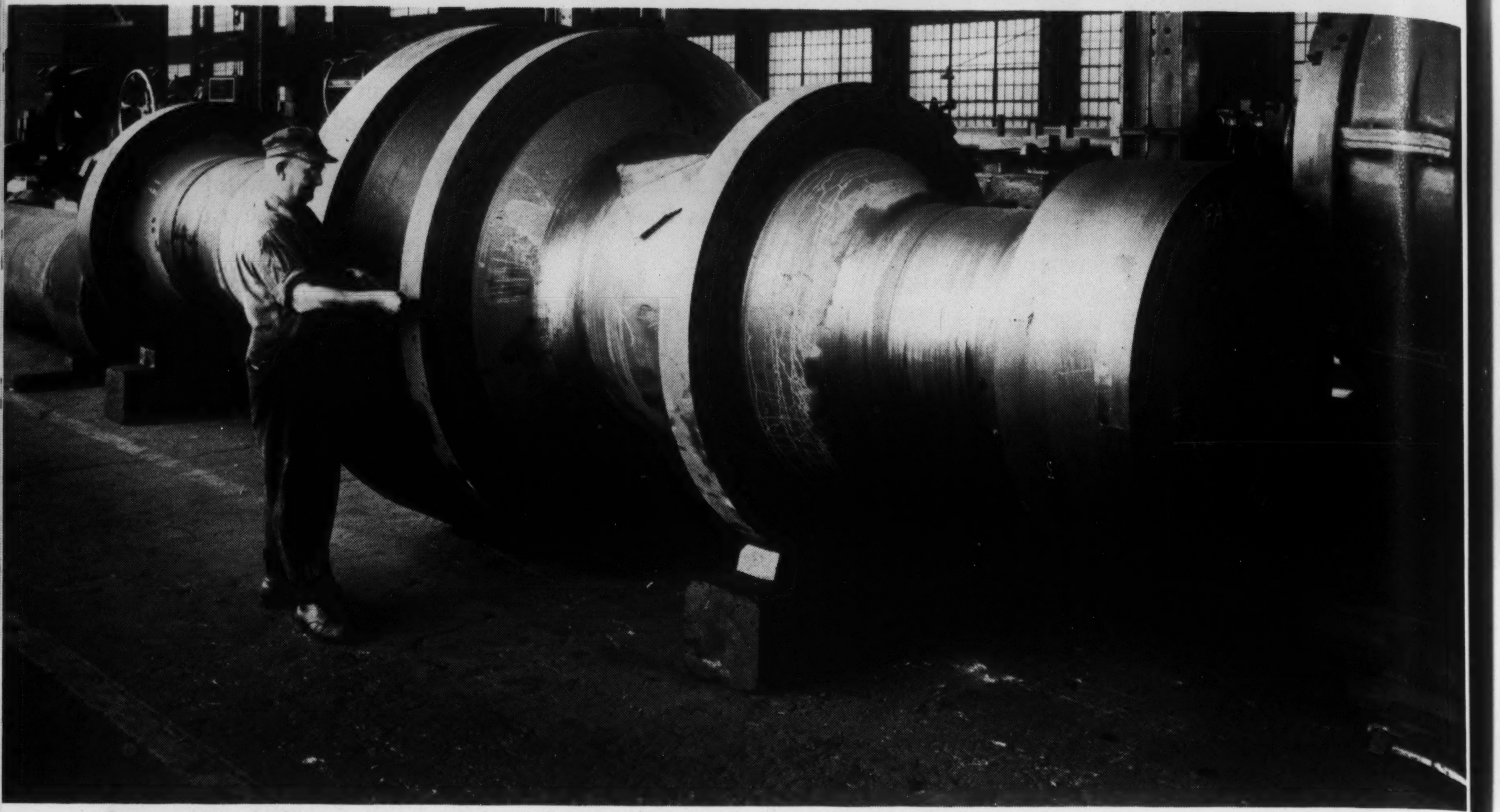
To form a recess or pocket in a forged part a corresponding raised section must be machined into the die. Flow of metal is restricted by these raised sections and it is desirable to provide generous sweeps and maximum draft angles. Because these raised die sections may be heated to considerably higher temperatures than the rest of the die, rapid wear can occur. This will result in the formation of shallower impressions on successive parts.

Formation of a rib on a forged part requires a corresponding thin pocket in the die. As the metal flows into this pocket, it may be cooled sufficiently to reduce the flow, with the result that the rib section may not be completely filled. Ribs should be designed as low and as wide as possible. It is also desirable to use full top radii and large draft angles on the rib sides.

The Drop Forging Assn. has established standard tolerances for closed die forgings to be used in the production of commercial and close tolerance parts. Tolerances for thickness, die wear, mismatching, draft angles, fillets and corners, and quantity are given in the accompanying tables. Tolerances obtainable are influenced by 1) differences in shrinkage from one forging to another, 2) die temperature, 3) finish forging temperature, 4) mismatch, 5) die closure, 6) die wear, and 7) distortion during heat treatment.

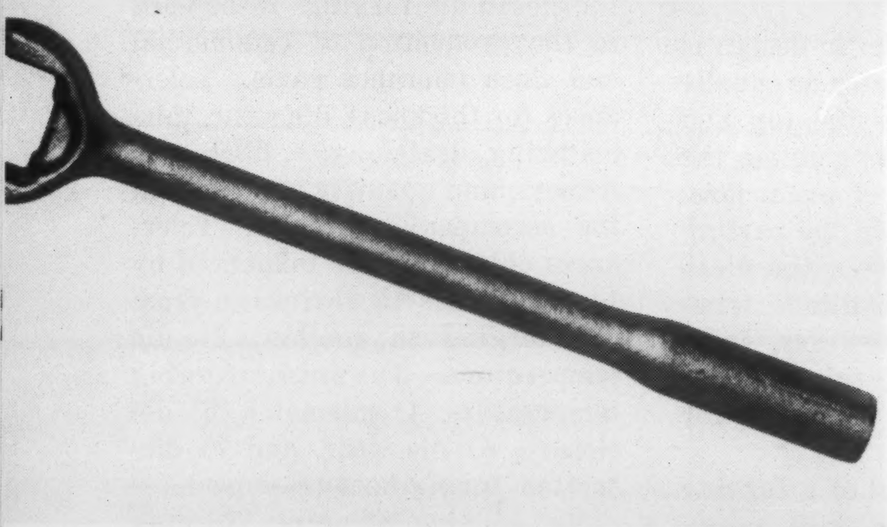
By suitable planning, forging costs and waste of metal can be reduced. In the production of multiple forgings, for example, correct grouping of the parts can reduce flash, and possibly the number of preforming operations. Another technique is forging two interdependent parts together. This method has been used to produce bevel gears and pinions as a unit, reducing die costs and using little more material than would be required for one part alone. In ring forging, material can be saved by piercing the pancake in such a way that the material removed can be used to produce a smaller ring.

Steel forgings: typical parts . . .



Generator shaft *weighing 45,000 lb, is produced in an open die forging press.*

Bethlehem Steel Co.

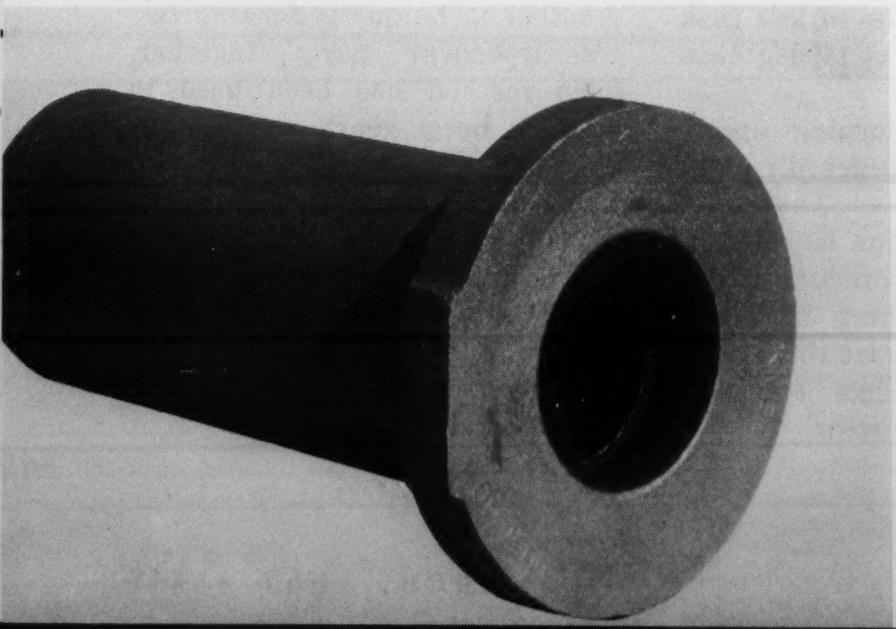


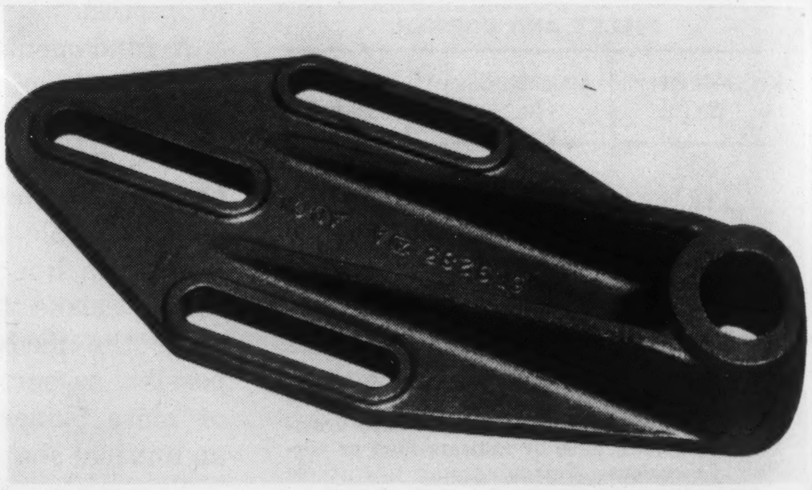
American Brake Shoe Co.

Combination universal joint *and drive shaft is made by upset forging the fingers, hammer forging the shaft.*

Rear axle *for tractor is forged from tube stock to save weight and material.*

American Brake Shoe Co.



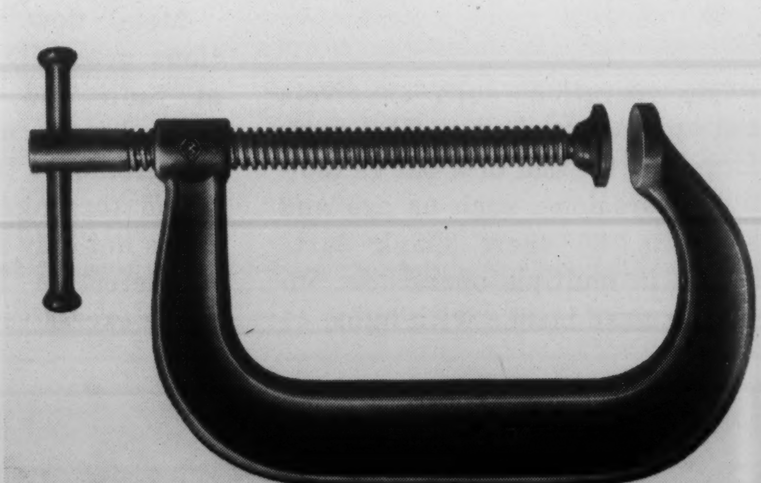


American Brake Shoe Co.

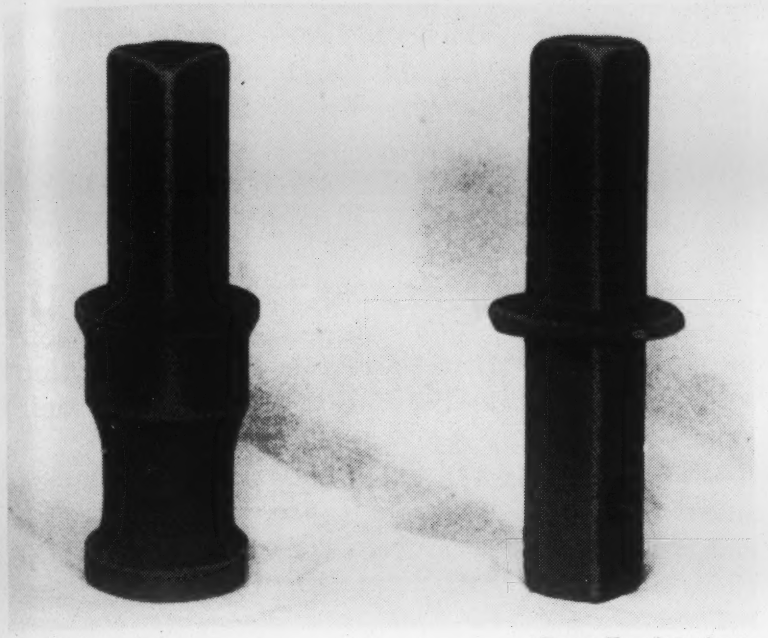
Fan bracket *for tractor is forged with deep ribs, pierced slots and hole to reduce weight and machining time.*

C-clamp *is forged from hot rolled 1045 steel bar having a Brinell hardness of 235 to 269. Bending before forging retains best fiber direction. This steel is suitable for a wide range of sizes, is readily forged and yields long die life.*

J. H. Williams & Co.



. . . and some redesigns



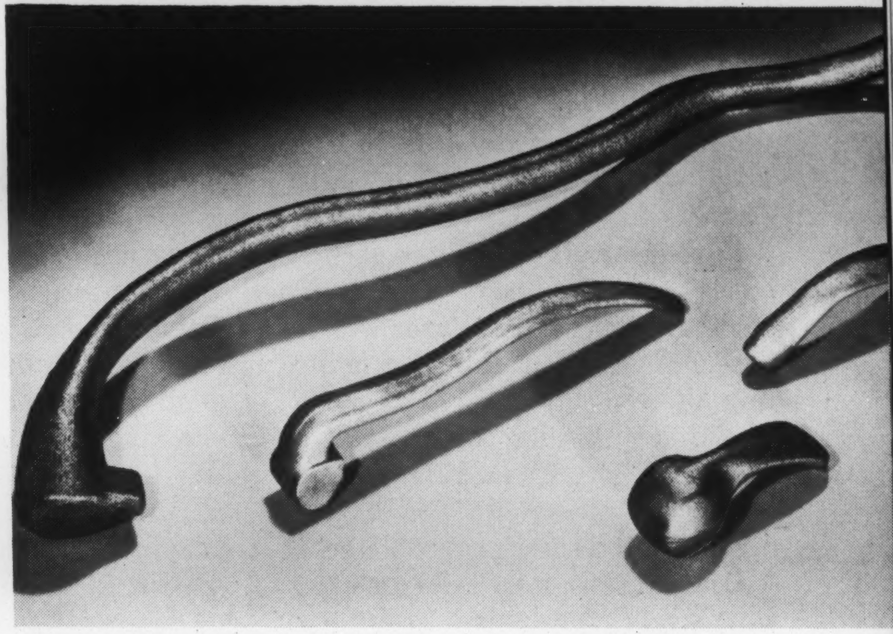
Drop Forging Assn.

Auger couplings *for earth drilling equipment.*

Old: Cast steel

New: Forged A4140 steel heat treated to Rockwell C25-30

Advantages: Closer tolerances, lower cost, 90% reduction in rejects.



Drop Forging Assn.

Dental chair parts *shown here are lock and slide levers for head and back rests.*

Old: Cast steel

New: Forged SAE 1020 and 1045 steels. Head rest lock and slide levers are heat treated to Rockwell C60

Advantages: Parts require chromium plating and surface finish is important. Cast parts had high rejection rate because of pitted surfaces; forged parts have improved surface finish and rejection rate is much lower. Forged parts are produced in less time and with less material.

American Brake Shoe Co.

Part for trailer axle *of large tandem trailer.*

Old: Cast steel

New: Forged steel

Advantage: Lower breakage, greater strength, lighter weight

Materials for Forgings

One of the principal advantages of forgings is the wide range of materials that can be employed. Literally hundreds of alloys can be shaped under the forging hammer or press. Some of the major classes of forging materials are discussed briefly in the remainder of this manual. All of these materials, despite individual differences, have certain requirements in common: the forging stock, be it billet, bloom, bar or extrusion, must be hot workable and it must be internally sound and free from surface defects.

Iron and steel

The first forgings were probably made of iron, and ferrous metals are still used for most forgings. In fact, more than two-thirds of all forgings are produced from carbon steels; alloy steels make up a considerable portion of the remaining tonnage. (For information on forging steels, consult the ASTM Standards listed on page 144.) The discussion on forging processes and design in the preceding sections applies particularly to ferrous metals, and the tolerances given in the tables, though applicable to other metals, were also developed for ferrous alloys. Modifications required in forging other materials will be discussed in later sections.

Carbon steels—Straight carbon steels are the most economical steels produced and are widely used. They are classified roughly into three groups: 1) low carbon steels, containing up to 0.20-0.25% carbon, 2) medium carbon steels, containing 0.25 to 0.50% carbon, and 3) high carbon steels.

Low carbon steels are employed extensively for parts requiring moderate strength. They are used without heat treatment but can be carburized for additional surface hardness. Typical forgings produced from low carbon steel are wrist pins, covers, machine arms, latches and cams.

Medium carbon steels are stronger than the low carbon grades and can be heat treated to improve properties. They are probably the most widely used steels. Applications include shafts, valves, connecting rods, machine parts and gear blanks.

Higher carbon steels are always used in the heat treated condition to obtain high strength and improved wearing properties. These steels are particularly adapted to the production of large forgings with heavy cross sections. Applications include diesel engine parts, large shafting and valves.

Alloy steels—Commercial alloy steels comprise a wide range of compositions based on the addition of nickel, chromium, molybdenum, vanadium or other elements in various combinations. The carbon content of these steels falls in the same ranges as it does in the straight carbon steels. Alloying elements are added to steel to increase hardenability or to improve such properties as strength, toughness and wear resistance. The advantages of alloy additions are obtained only by heat treating the forgings. Although increasing the alloy content generally increases strength, it also increases the difficulties of forging, heat treating and machining.

Alloy steels are generally selected for highly stressed parts of machines, engines, transportation equipment, etc. Selection of the best grade depends on design and shape of the part, type of wear expected, static or dynamic service conditions, and the service life which is expected.

Stainless steels — The stainless steels can be grouped into 1) straight chromium hardenable grades, 2) straight chromium nonhardenable grades, and 3) nonhardenable chromium - nickel grades. Most of these alloys can be readily forged. Although they are considerably more expensive than the lower alloy steels, their increased resistance to corrosion and oxidation often justifies their use.

Stainless steel forgings are widely used for valves, fittings, pressure vessels and similar applications in the process industries, oil fields, sewage plants, etc.

Tool steels—Quite a number of proprietary tool steels are forged into die blocks. This is a highly specialized portion of the forging industry, and the die block producer should be consulted in determining the proper grade of steel to use. Applications include press and hammer dies, gripper and header dies, extrusion dies, nosing dies and hot punches.

Wrought iron—Any of the common forging methods can be used in producing parts from wrought iron. It is an easy metal to forge, although forging temperatures are higher than those used for low

ASTM Specifications Covering

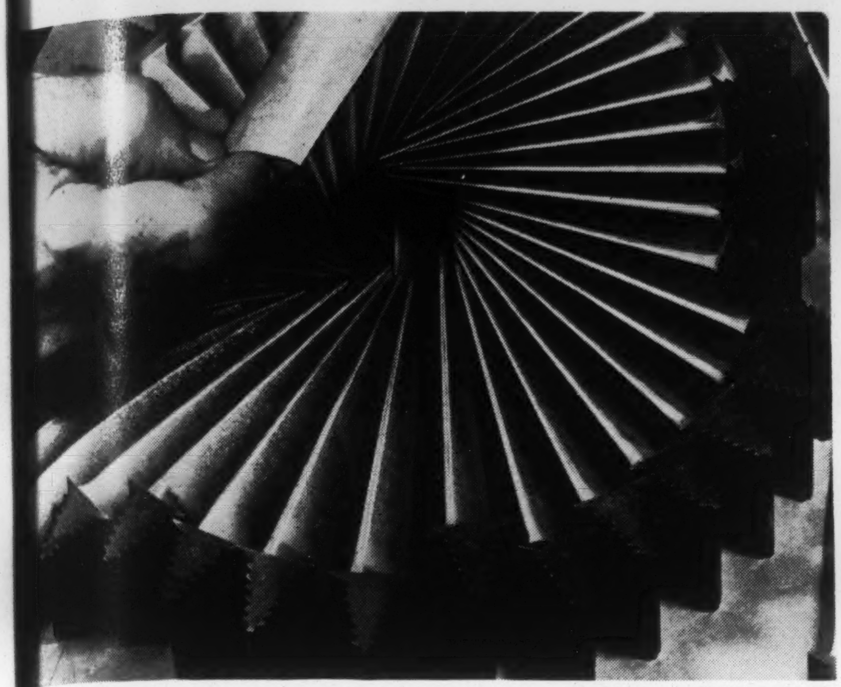
Carbon Steels

A 21-55T	Carbon Steel Axles, Non-Heat Treated for Railway Use
A 105-55T	Forged or Rolled Steel Pipe Flanges, Forged Fittings and Valves and Parts for High Temperature Service
A 181-55T	Forged or Rolled Steel Pipe Flanges, Forged Fittings and Valves and Parts for General Service
A 235-55	Carbon Steel Forgings for General Industrial Use
A 236-55	Carbon Steel Forgings for Railway Use
A 266-55	Carbon Steel Seamless Drum Forgings
A 273-54	Carbon Steel Blooms, Billets and Slabs for Forgings

Carbon and Alloy Steels

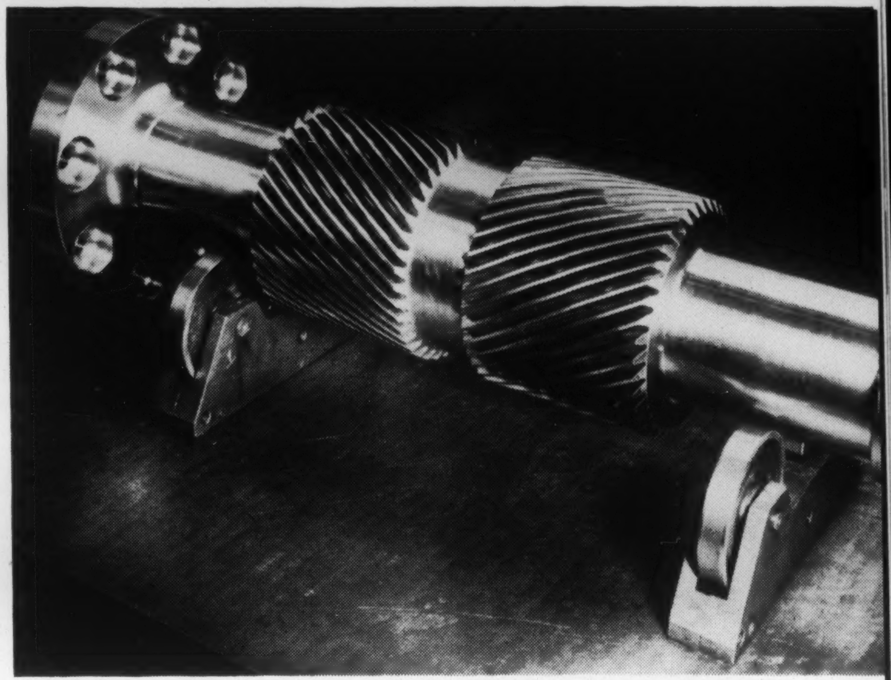
A 234-52aT	Factory Made Wrought Carbon Steel and Ferritic Alloy Steel Welded Fittings
A 243-55	Carbon and Alloy Steel Ring and Disk Forgings
A 288-55	Carbon and Alloy Steel Forgings for Magnetic Retaining Rings for Turbine Generators
A 290-55	Carbon and Alloy Steel Forgings for Rings for Reduction Gears
A 291-55	Carbon and Alloy Steel Forgings for Pinions for Reduction Gears
A 292-55	Carbon and Alloy Steel Forgings for Turbine Generator Rotors and Shafts
A 293-55T	Carbon and Alloy Steel Forgings for Turbine Rotors and Shafts
A 294-55	Carbon and Alloy Steel Forgings for Turbine Bucket Wheels
A 350-55	Forged or Rolled Carbon and Alloy Steel Flanges, Forged Fittings, and Valves and Parts for Low Temperature Service
A 372-55T	Carbon and Alloy Steel Forgings for Pressure Vessel Shells

Forgings are widely used for stressed parts at high temperatures



International Nickel Co.

Turbine buckets *for turbojet engines to withstand temperatures of 1600 F and centrifugal forces near 25,000 psi require heat resistant alloys. Buckets like these are forged from Inconel X, Nimonic 80A, Stellite 21, N-155, S-816, Waspaloy and 25-16-6.*



Westinghouse Electric Corp.

Pinion *forged from Discaloy and finish machined. Other applications include turbine disks, springs and extrusion die parts.*

carbon steels. A typical application is draw bars for locomotives. Forging is also used to flange wrought iron pipe ends to form Van Stone joints.

High temperature alloys

The high temperature alloys are a large group of highly alloyed iron, nickel or cobalt-base materials, many of them proprietary. Since they are designed to retain usable strengths for long periods at temperatures ranging up to 1500 F, they do not become as plastic as steels and, consequently, cannot be forged as readily. However, they are closer to the steels than to other alloys in their forging characteristics. High temperature alloy forgings are used for various aircraft engine parts, including disks and turbine blades.

Nickel, nickel alloys

Forging procedures for nickel alloys are similar to those for steel. However, high nickel alloys are

Forged Materials

Alloy Steels

A 182-55T	Forged or Rolled Alloy Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service
A 237-55	Alloy Steel Forgings for General Industrial Use
A 238-55	Alloy Steel Forgings for Railway Use
A 274-54	Alloy Steel Blooms, Billets and Slabs for Forgings
A 298-55	Alloy Steel Forgings for Nonmagnetic Coil Retaining Rings for Turbine Generators
A 336-55T	Alloy Steel Seamless Drum Forgings

Alloy and Stainless Steels

A 369-55T	Ferritic Alloy Steel Forged and Bored Pipe for High Temperature Service

Stainless Steels

A 314-55	Corrosion Resisting Steel Billets and Bars for Reforging

Wrought Iron

A 73-55	Wrought Iron Rolled or Forged Blooms and Forgings

Nickel

B 160-49T	Nickel Rods and Bars
B 164-49T	Nickel-Copper Alloy Rods and Bars
B 166-49T	Nickel-Chromium-Iron Alloy Rods and Bars

Copper

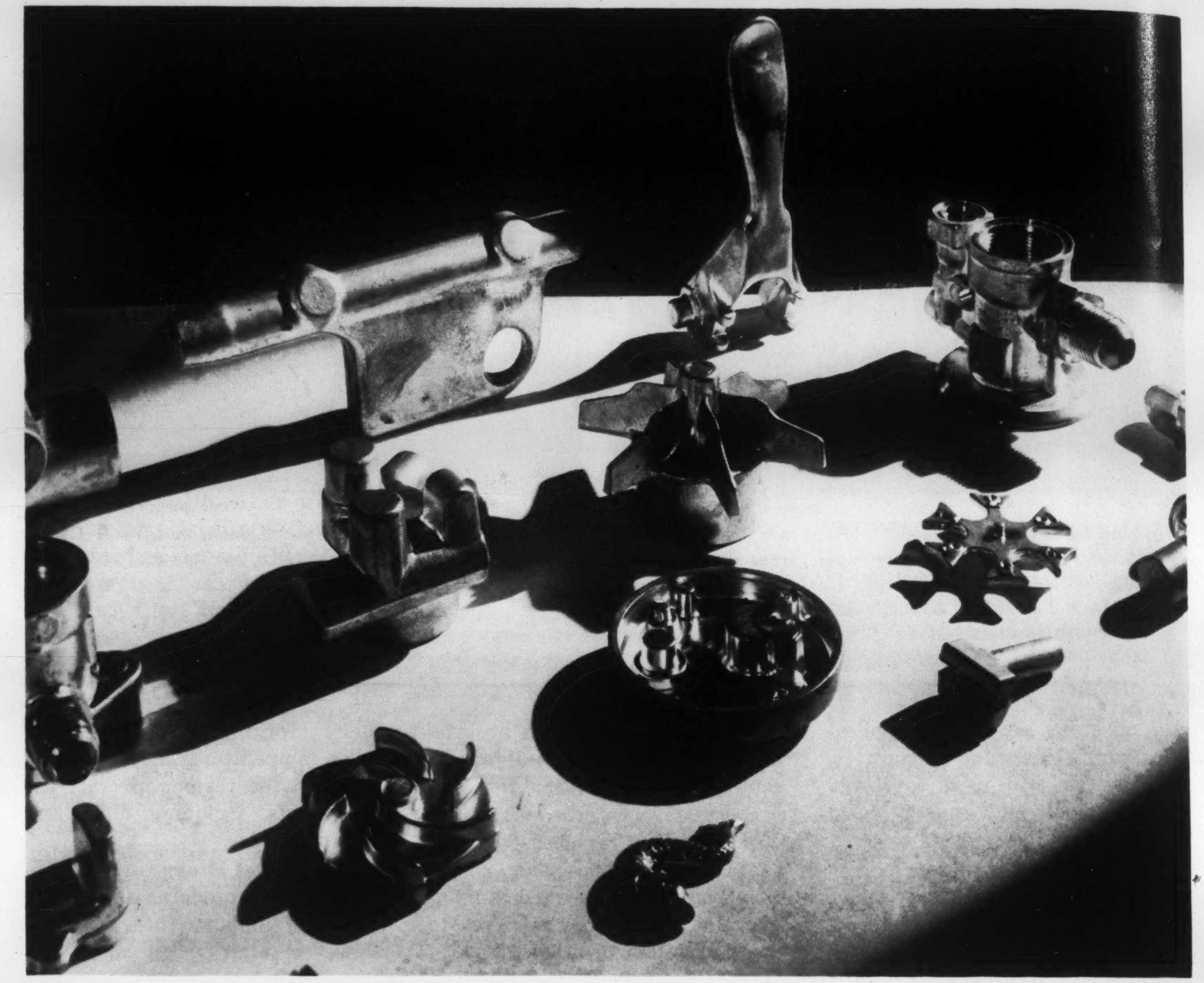
B 124-55	Copper and Copper Alloy Forging Rod, Bar and Shapes
B 283-56	Copper and Copper Alloy Die Forgings (Hot Pressed)

Aluminum

B 247-55T	Aluminum Alloy Die Forgings

Magnesium

B 91-56T	Magnesium-Base Alloy Forgings



Chase Brass & Copper Co.

Pressing in closed dies *is used in the production of practically all copper alloy forgings. Hammer closed die forging is seldom used and open die forging is confined to production of a limited number of special machine parts.*

considerably stiffer than steel at forging temperatures, and it may be necessary to use heavier equipment for some parts than is required in working steel. Forging temperatures generally range from 2300 to 1600 F, but depend on the composition. Nickel and monel can be finished in certain cases as low as 1200 F. Furnace atmosphere is important in heating nickel alloys for forging; high nickel alloys must be heated in atmospheres having low sulfur contents.

Forged parts are produced from nickel, monel, Inconel, K monel, Duranickel and Inconel X. K monel, Duranickel and Inconel X are precipitation hardenable alloys and should not be cooled slowly following hot working.

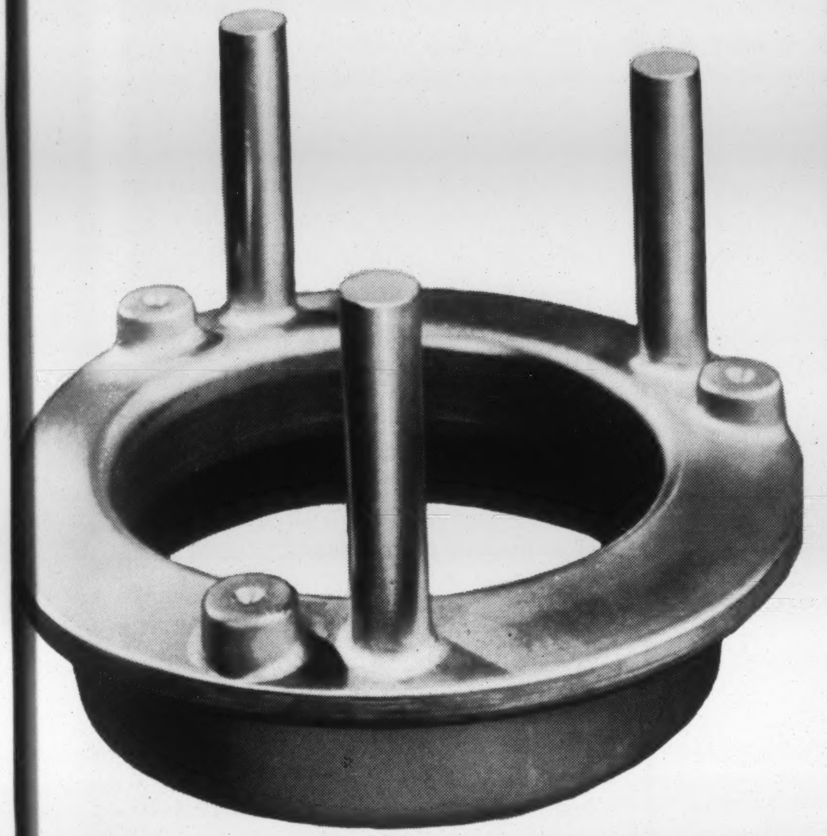
These materials have a wide range of applications, particularly for resistance to corrosion. Almost any shape that can be forged in steel can be duplicated in the nickel alloys. Typical applications include turbine blades, conveyor chain links, rings, hooks, pipe fittings, valves and valve trim.

Copper, copper alloys

Most copper alloy forgings are made by pressing in closed dies. Hammer closed die forging is seldom used, and open die forging is confined to production of a limited number of special machine parts. The major copper alloys used in forgings are copper, Muntz metal, forging brass, naval brass, manganese bronze, silicon bronzes and nickel silver 45-10.

Generally an extruded bar is used as the forging stock. This stock is forged in the range 1400 to 1600 F, depending upon composition. Considering such factors as hot plasticity, die wear and pressure, forging brass is the easiest to forge and high silicon

. . . and some redesigns



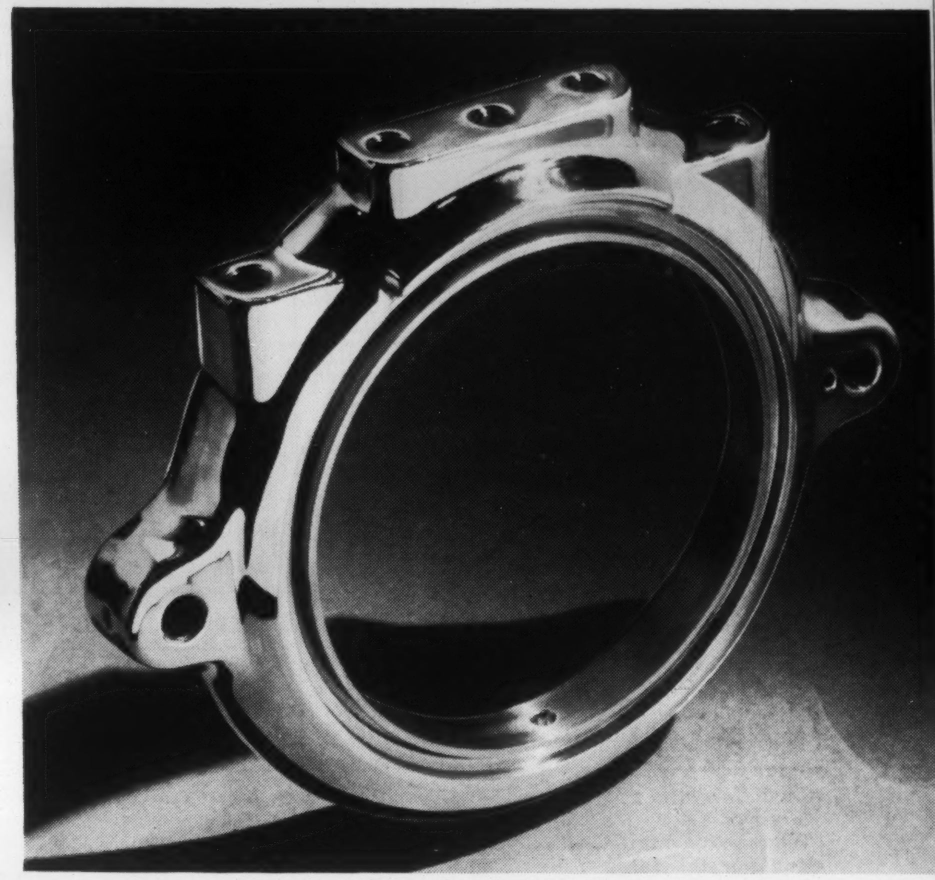
Titan Metal Mfg. Co.

Main valve seat *for fire plug.*

Old: Sand-cast brass

New: Forged brass

Advantage: Because sand-cast pegs bent easily, fire plug did not operate correctly. Increased strength of forgings overcame difficulty and reduced cost of part



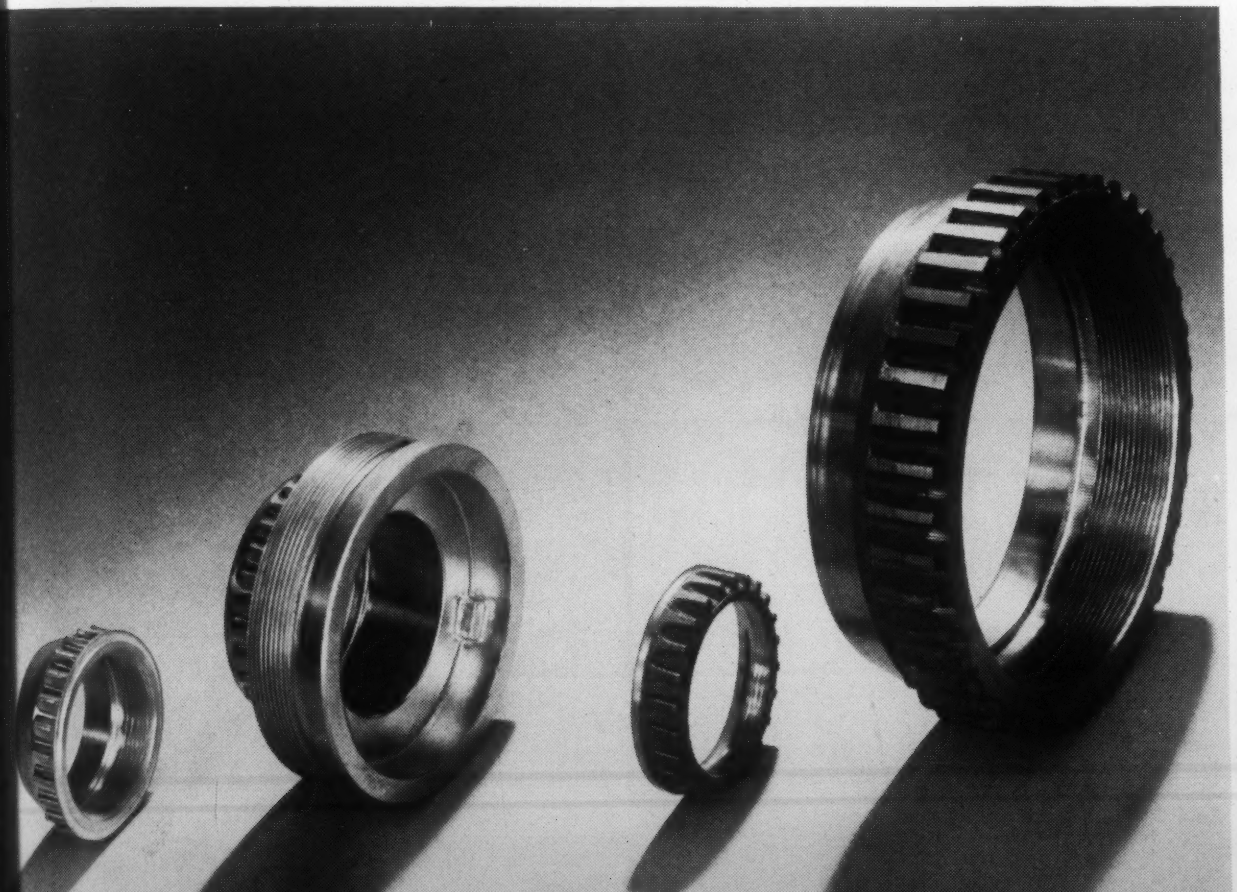
Drop Forging Assn.

Collar *for autoclave.*

Old: Cast brass

New: Forged brass

Advantages: Simplified production, less material required, and improved surface quality produced an over-all cost saving of 25%



Copper & Brass Research Assn.

Valve control rings *for use in a safety valve. Two rings at left are forged; two at right are cast.*
Old: Cast brass
New: Forged brass
Advantage: 33% cost reduction through less cleaning and machining

COMMERCIAL TOLERANCES FOR HOT PRESSED COPPER AND COPPER ALLOY FORGINGS[a, b]

	Copper	Brasses[c]	High Silicon Bronze	Aluminum Silicon Bronze	Nickel Silver 45-10
	Tolerances, in.				
Forging Type					
1—Solid	0.010	0.008	0.012	0.010	0.008
2—Solid—Symmetrical Cavity	0.010	0.008	0.012	0.010	0.008
3—Solid—Eccentric Cavity	0.012	0.008	0.012	0.012	0.008
4—Solid—Deep Extrusion	0.012	0.010	0.014	0.012	0.010
5—Hollow—Deep Extrusion	0.012	0.010	0.014	0.012	0.010
6—Thin Section—Short (up to 6 in.)	0.012	0.010	0.014	0.012	0.010
7—Thin Section—Long (6 to 14 in.)	0.015	0.015	0.020	0.015	0.015
8—Thin Section—Round	0.012	0.010	0.014	0.012	0.010
Machining Allowance (one surface)	1/32	1/32	1/32	1/32	1/32
Flatness, max deviation per in.	0.005	0.005	0.005	0.005	0.005
Concentricity, total indicator reading	0.030	0.020	0.030	0.030	0.030
Draft Angle (outside and inside, 1-5 deg)	½ deg	½ deg	½ deg	½ deg	½ deg
	Dimensions and Tolerances, in.				
Nominal Web Thickness, in.[d]	5/32	1/8	3/16	5/32	1/8
Nominal Fillet and Radius, in.[d]	3/32	1/16	1/8	3/32	1/16
Approx Flash Thickness, in.	1/16	3/64	5/64	1/16	3/64

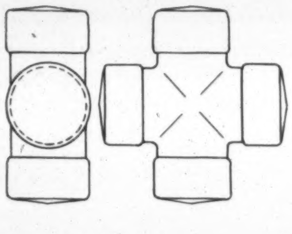
[a] Small forgings up to 2 lb incl. Consult producer for tolerances applicable to heavier forgings.

[b] Tolerances are plus and minus. For all plus or all minus tolerances, double values given.

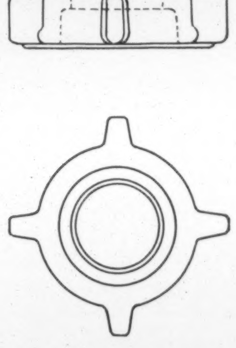
[c] Muntz metal, forging brass, naval brass, leaded naval brass, manganese bronze.

[d] Tolerance is 1/64 in.

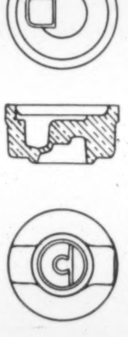
Source: Copper & Brass Research Assn.



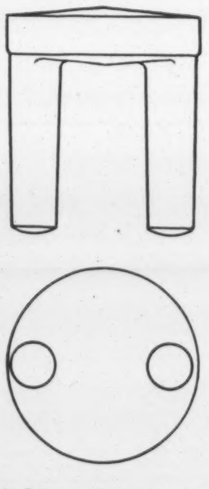
1. Solid



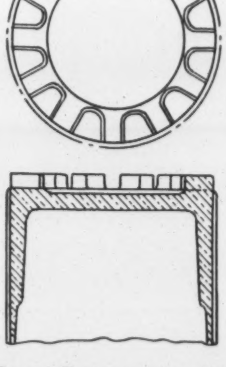
2. Solid with Symmetrical Cavity



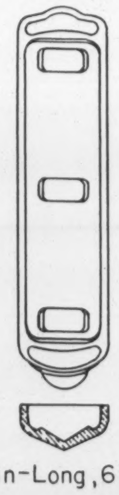
3. Solid with Eccentric Cavity



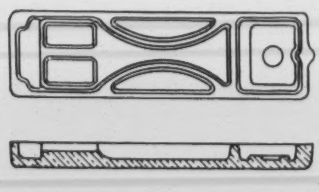
4. Deep Extrusion-Solid



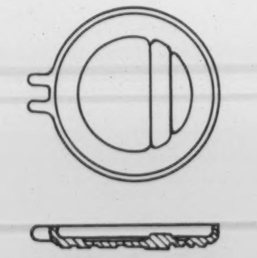
5. Deep Extrusion-Hollow



7. Thin-Long, 6 to 14 in.



6. Thin - Short to 6 in.



8. Thin - Round

bronze the most difficult of the materials mentioned above.

Tolerances that can be maintained commercially on copper alloy forgings weighing up to 2 lb are given in the accompanying table. The producer should be consulted for tolerances applicable to larger sizes because they are affected by shape and other factors. These tolerances differ somewhat from those suggested by the Drop Forging Assn.

Selection of the proper copper alloy depends on the properties desired in the finished part. For example, copper would be selected if a major requirement were high electrical conductivity, naval brass for corrosion resistance in marine environments, and a leaded alloy such as forging brass for economical machining.

Copper and copper alloy forgings are used for plumbing fittings, chemical and food processing equipment, refrigeration equipment, hardware, marine fittings, etc.

Aluminum, aluminum alloys

In general, aluminum alloys are forged by the procedures described for steel. However, forging temperatures are lower, ranging from 750 to 900 F. The exact temperature varies with the alloy and for best results must be closely controlled. The metal is not as plastic as steel at the forging temperature; therefore, heavier presses and more massive dies are required than would be needed to produce the same part from steel. Reasonable die life can be obtained, however, because of the moderate forging temperature. Tolerances that can be maintained on aluminum alloys are given in the tables on page 150.

Aluminum forging alloys generally contain copper, silicon or both, and small quantities of magnesium. Other elements are sometimes added to impart specific properties to the alloy. The major forging alloys are 2014, 2018, 2218, 2025, 4032, 6151, 6061 and 7075.

Alloy 2014 is recommended for general structural applications. It has reasonably good forging qualities and good machinability. Alloy 6151 is the easiest to forge of all commercial aluminum alloys and has excellent machinability. It is particularly suited for low cost parts that do not require extremely high strength. Alloy 7075 is a high strength forging alloy which is less readily forged than the other alloys and is more costly. It is used where its high properties justify the additional manufacturing expense. Alloys 2018, 2218 and 4032 withstand high stresses at elevated temperatures. Alloy 2025 is a special purpose material used only for aircraft propellers, impellers and similar parts.

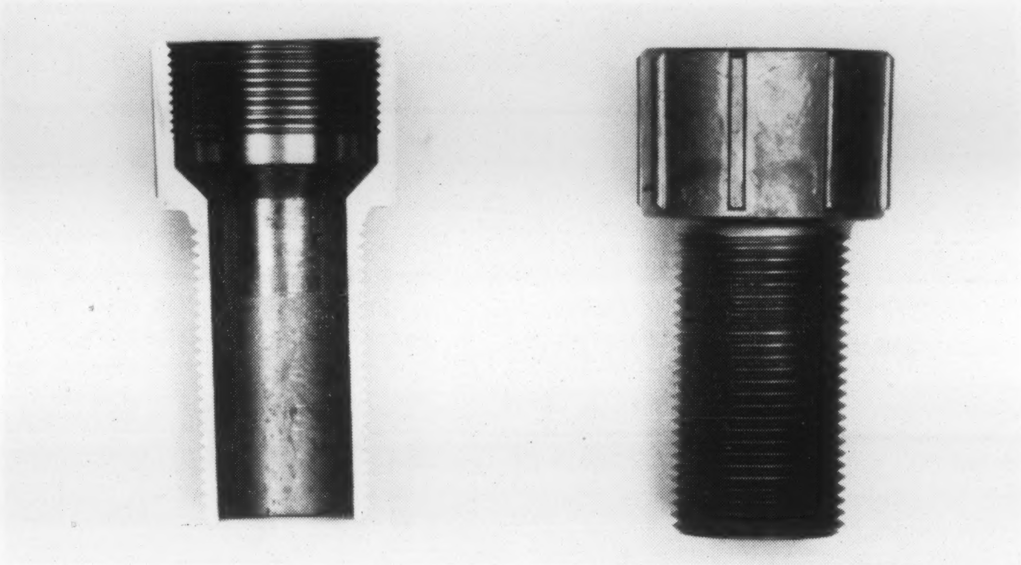
Some indication of the applications of aluminum forgings are given in the previous paragraph. Specific applications include aircraft engine crankshafts, pistons for internal combustion engines, supercharger impellers, aircraft propellers, wing sections and cylinder heads.

Magnesium alloys

Forging practice for magnesium alloys is similar to that for aluminum. However, some of the stronger alloys cannot be hammer forged and are therefore formed by pressing. Magnesium alloys have narrow plastic ranges and forging temperatures must be closely controlled within the range.

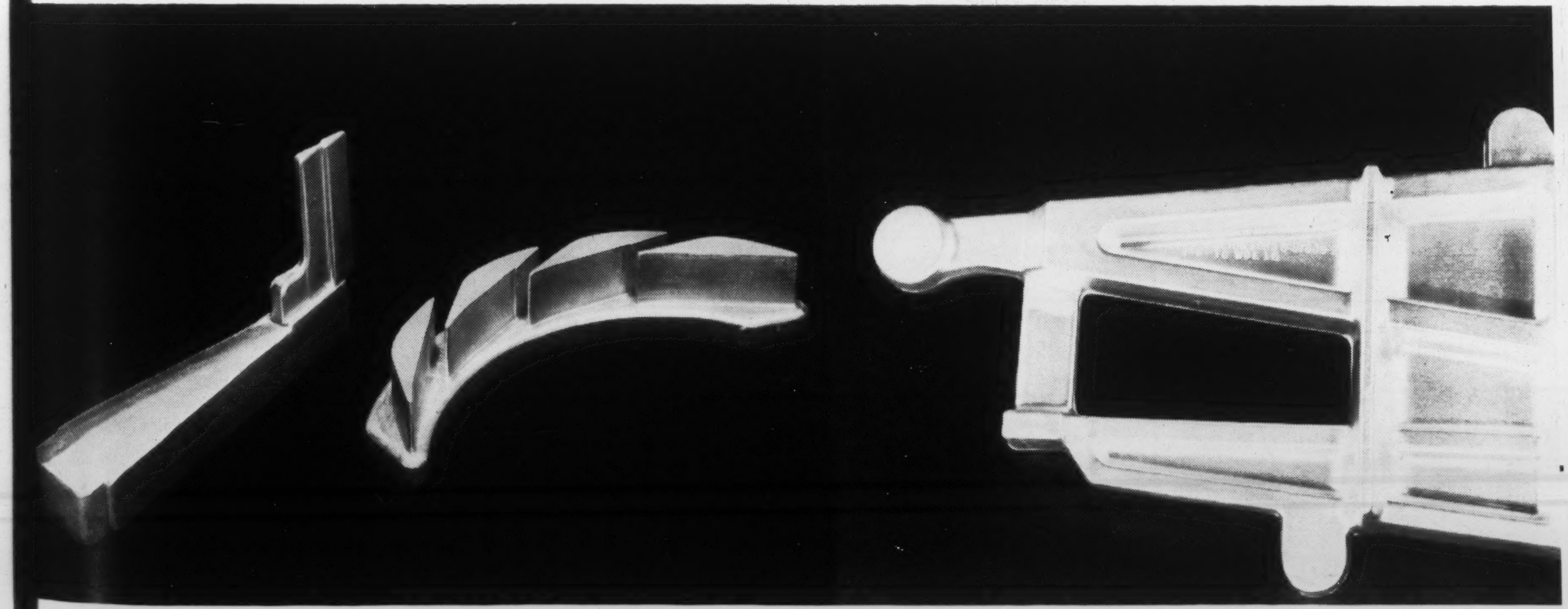
Magnesium alloys differ from aluminum because repeated reheatings may cause excessive grain growth. Consequently, most magnesium forgings are produced with only two or three forging operations. Since magnesium does not flow as readily as aluminum, radical changes in section are difficult to form; the design should be kept as simple as possible. Suggested tolerances for magnesium alloys are given in the tables on the following page.

Magnesium forging alloys generally contain aluminum and zinc with or without minor additions of other elements. The ASTM



Titan Metal Mfg. Co.

Cored brass forgings *of simple shape produced by special die arrangement (threads were machined). Cored forging, a relatively recent development, permits the formation of hollow or tubular parts during pressing. A closed die is equipped with pegs that are positioned mechanically just before pressure is exerted. The brass is deformed plastically to flow around the pegs and fill the die cavity. Pegs are withdrawn automatically before die opens. Various components can be produced by cored forging but in most cases it is necessary to leave a web of metal about 3/32 to 1/8 in. thick between punches entering the forging from opposite sides.*



Kaiser Aluminum & Chemical Corp.

Aircraft components *forged from 2014 aluminum and heat treated to the T-6 condition. From left to right: splice fitting, vane assembly and hinge support.*

lists the following forging alloys: TA54A, AZ31B, AZ61A, AZ80A and ZK60A.

Alloy TA54A is the best magnesium alloy for hammer forging. AB31B has better press forging characteristics than the other alloys and can also be hammer forged. AZ80A is suitable for press forgings of relatively simple design in which high strength is required. Alloy ZK60A has excellent press forging properties and the best combination of strength and ductility of the magnesium forging alloys.

Magnesium forgings are used particularly for structural parts, engine components and fittings in aircraft.

Titanium

The forging of titanium and its alloys has reached the production stage, and considerable information on procedures is available. In flow characteristics, titanium is closer to aluminum than to steel. Titanium alloys are comparable with 7075 aluminum in forging properties, and the same equipment can be used. Special dies must be used for several reasons: 1) differences in shrinkage characteristics, 2) difficulty in forging thin sections because of rapid work hardening, and 3) need for large radii and fillets because of difficulty in filling die contours. Intricate forgings generally require more stages in titanium than in steel.

Because titanium is a reactive metal, heating for forging must be done rapidly to prevent absorption of oxygen and nitrogen and resulting formation of a hard surface skin. Also, hydrogen content of the atmosphere must be low to prevent embrittlement. Forging temperatures range from about 1550 to 1650 F and must be controlled closely. Flash should be removed while the forging is still warm, and a stress relief heat treatment at 1100 to 1300 F should follow as soon as possible.

The principal forging alloys are 4 manganese-4% aluminum; 6 aluminum-4% vanadium; and 2 iron-2 chromium-2% molybdenum. Commercially pure titanium is also forged.

Applications of titanium forgings have been limited generally to aircraft components. Parts include compressor blades, engine rings, compressor disks, torque arms, structural parts and fittings.

STANDARD TOLERANCES FOR LIGHT METAL FORGINGS

LENGTH OR WIDTH

Dimension, in.	Exterior Dimensions, in.		Interior Dimensions, in.		Step and Center Dimensions, in.
	Plus	Minus	Plus	Minus	Plus or Minus
Up to 8	0.032	0.016	0.016	0.032	0.016
Over 8, add per in.	0.004	0.002	0.002	0.004	0.002
For example:					
24	0.096	0.048	0.048	0.096	0.048
60	0.240	0.120	0.120	0.240	0.120
96	0.384	0.192	0.192	0.384	0.192

STRAIGHTNESS

Length, in.	Tolerance, in.
0 up to 9	1/64
9 up to 18	1/32
18 up to 30	3/64
30 up to 45	1/16
45 up to 60	3/32
60 up to 80	1/8

DIE CLOSURE

Magnesium,[a] lb	Aluminum,[a] lb	Tolerance, in.	
		Plus	Minus
0 up to ¼	0 up to ¼	0.032	0.010
¼ up to 1	¼ up to 1	0.032	0.015
1 up to 3	1 up to 4	0.045	0.032
3 up to 11	4 up to 17	0.002	0.032
11 up to 16	17 up to 24	0.078	0.032
16 up to 33	24 up to 50	0.093	0.032
33 up to 67	50 up to 100	0.125	0.045
67 up to 170	100 up to 250	0.187	0.062
170	250	0.250	0.062

[a]Net weight of forging.

Source: Aluminum Co. of America

MISMATCH

Magnesium, lb[a, b]	Aluminum, lb[a, c]	Tolerance, in.
0 up to 1	0 up to 1	0.015
1 up to 5	1 up to 7	0.018
5 up to 9	7 up to 13	0.021
9 up to 13	13 up to 19	0.024
13 up to 17	19 up to 25	0.027
17 up to 21	25 up to 31	0.030
21 up to 25	31 up to 37	0.033
25 up to 29	37 up to 43	0.036
29 up to 33	43 up to 49	0.039
33 up to 37	49 up to 55	0.042

[a]Net weight of forging. Long, narrow forging may require larger mismatch tolerances. To be determined by forging vendor.

[b]Magnesium: for each 1-1/3 lb exceeding 37, add 0.001 in. to tolerance.

[c]Aluminum: for each 2 lb exceeding 55, add 0.001 in. to tolerance.

DRAFT ANGLE

Draft Angle	Tolerance
Up to 3 deg	± ½ deg
3 deg and above	± 1 deg

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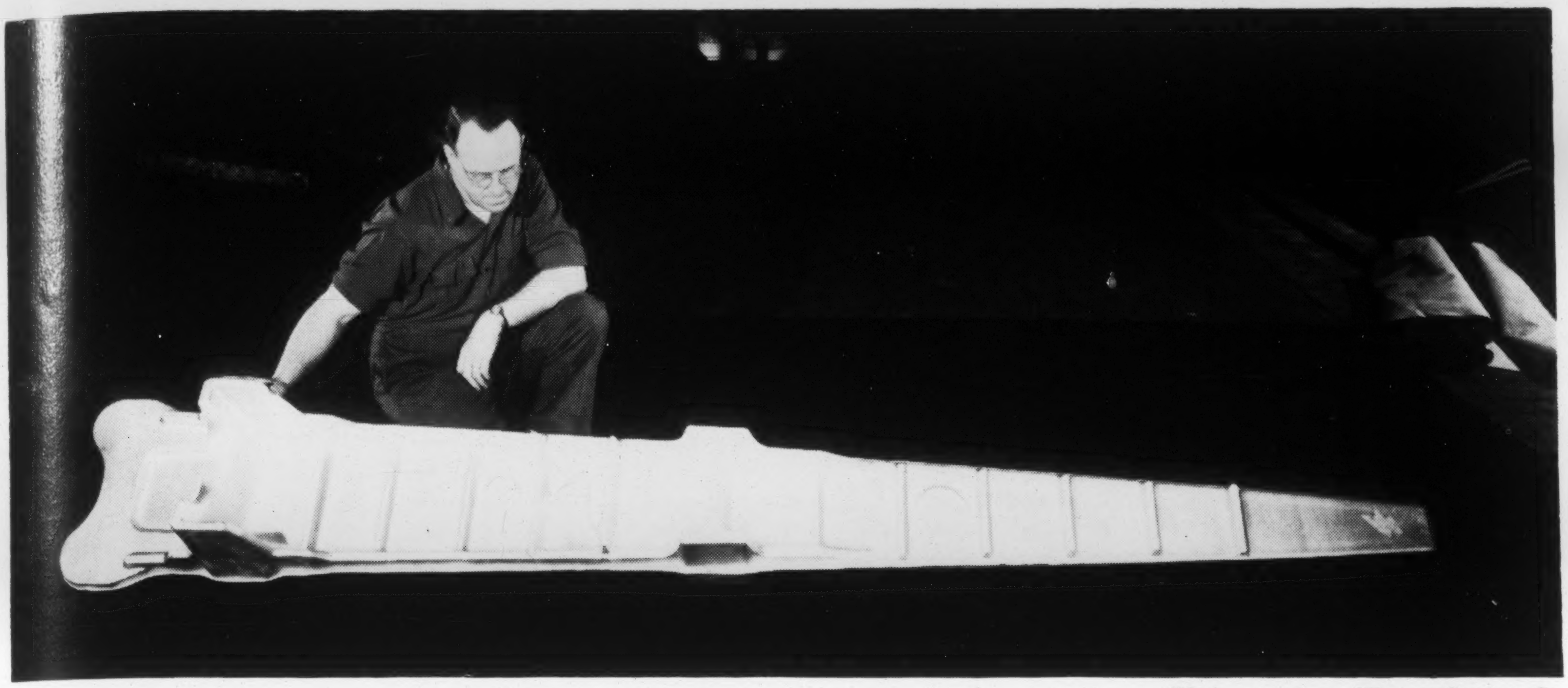
Why large aluminum forgings are used: two case histories



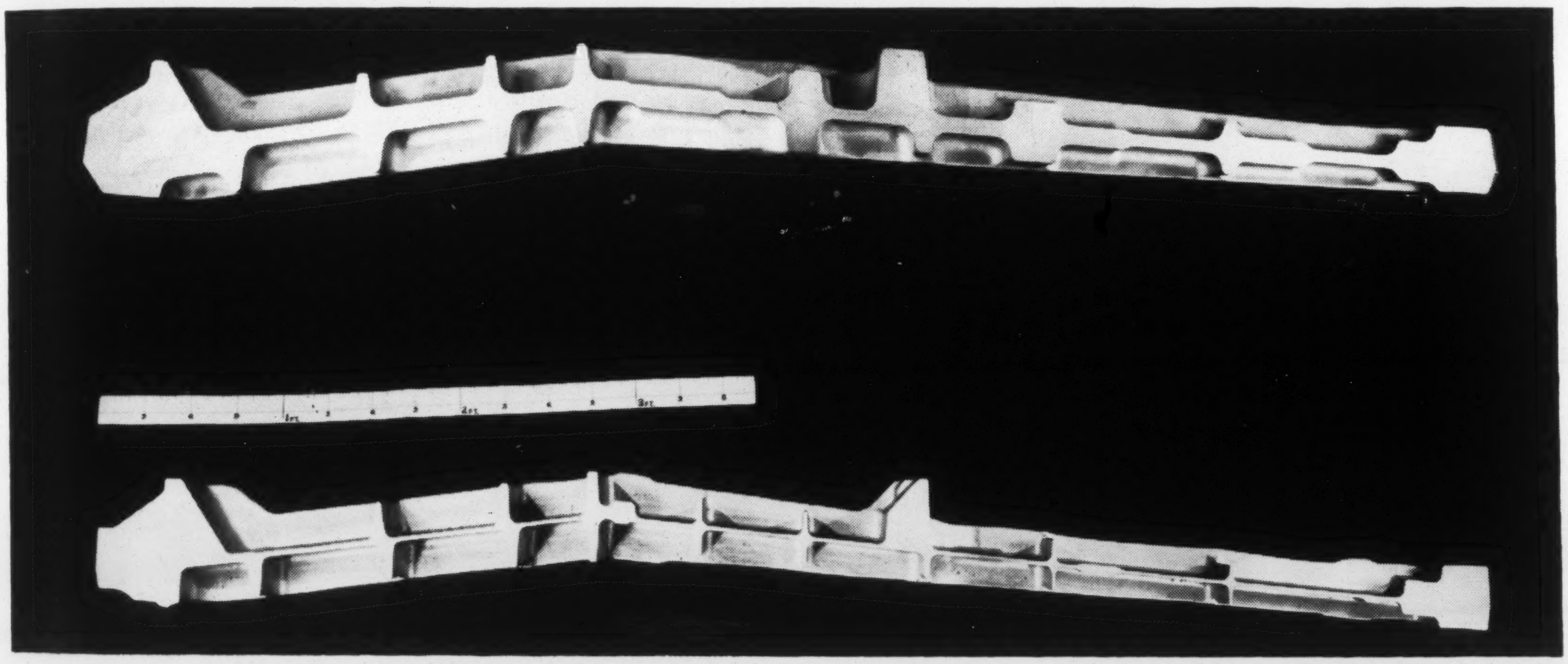
Photos courtesy Wyman-Gordon Co.

Delta wing spar forging *of 7075-T6 aluminum for F-102A supersonic interceptor is 10 ft, 6 in. long and 18 in. wide with webs 3/16 in. thick.*

Old: Assembly of 64 pieces and 800 rivets

New: One piece forging produced on 35,000-ton hydraulic press

Advantage: Four forgings are used in each plane, saving 100 lb in weight



Source: Aluminum Co. of America

Cross sections *of forged aluminum parts show advantages of close tolerances and reduced draft achieved by pressure forging in heavy presses.*

Old: Conventional forging (top)

New: Close tolerance forging

Advantages: Thinner web and ribs save 20% in machining cost, 25% in material

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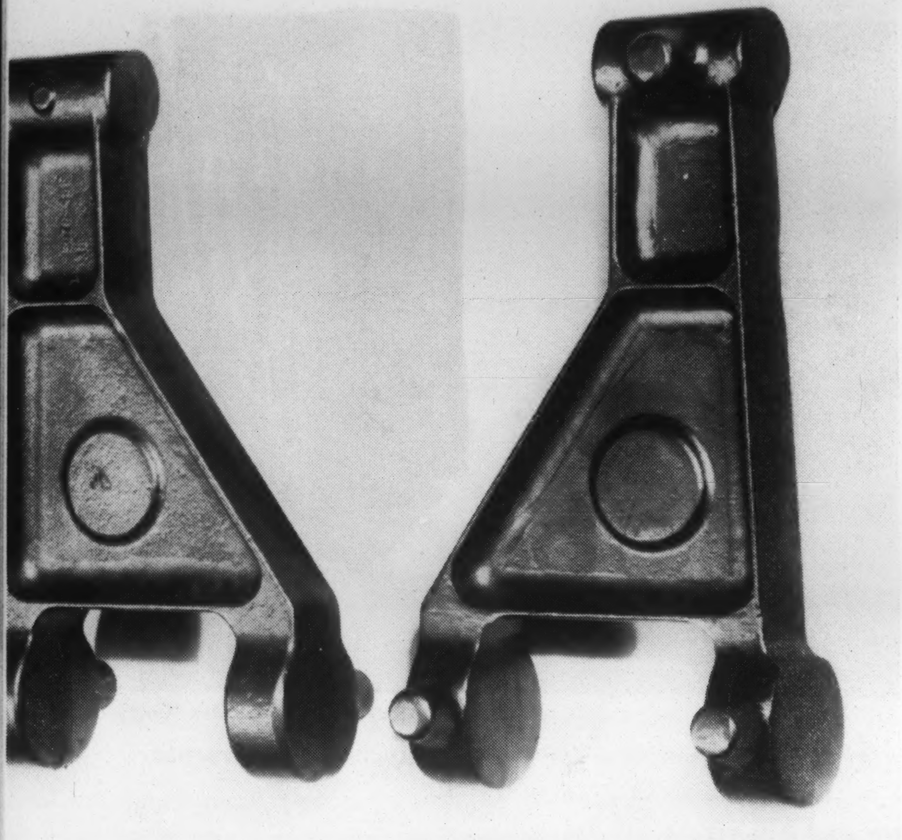
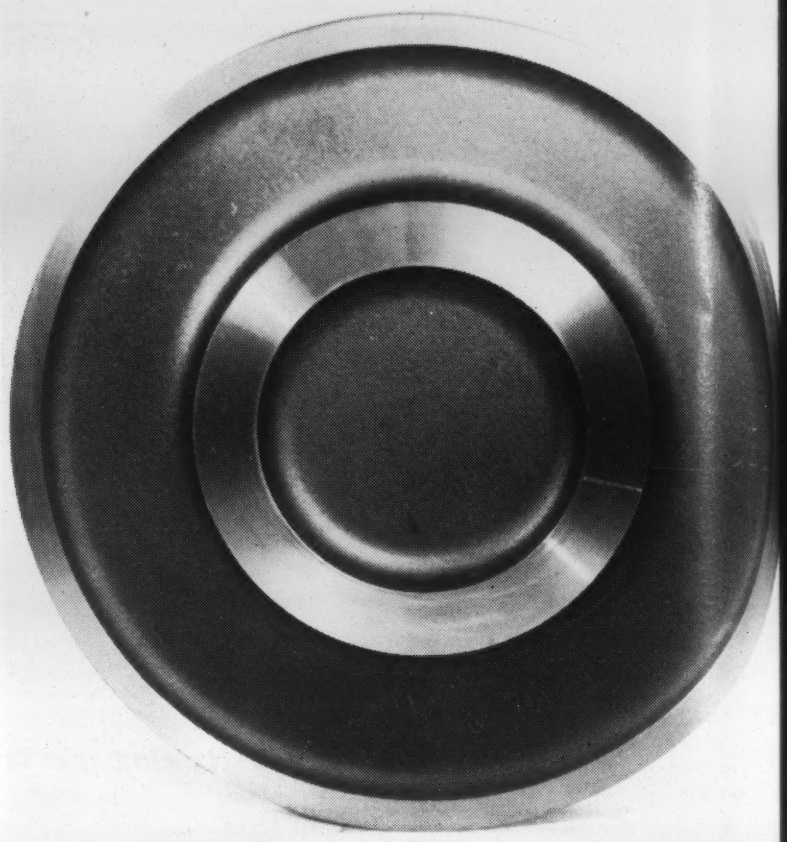
Typical titanium forgings are . . .

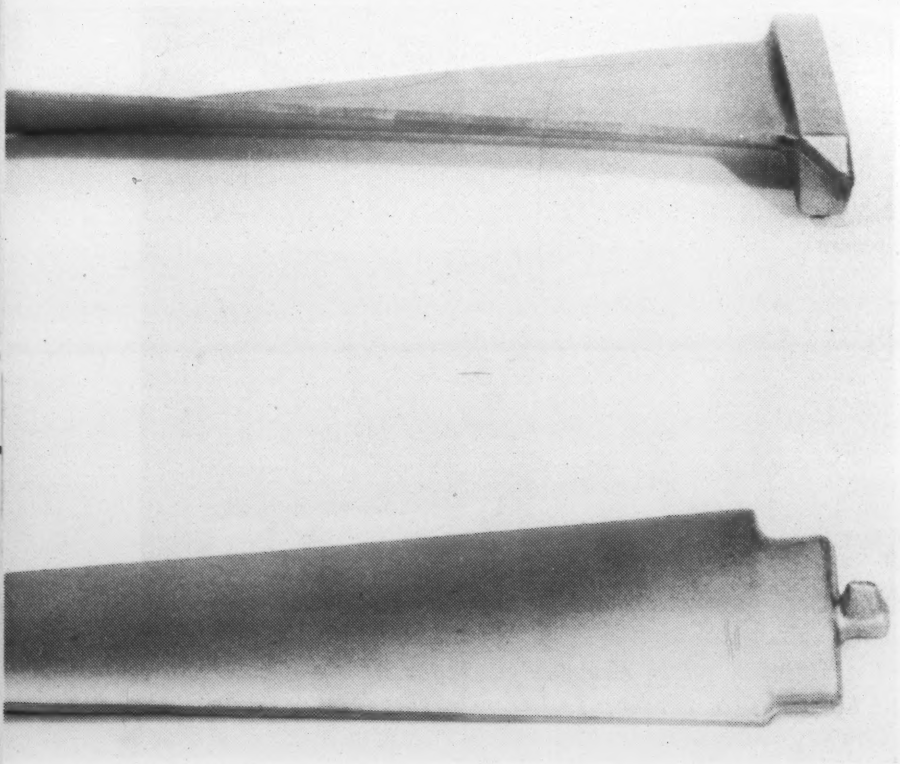


Photos courtesy Steel Improvement & Forge Co.

Landing gear torque arm, *forged from alloy containing 4 manganese and 4% aluminum; it weighs 2.6 lb.*

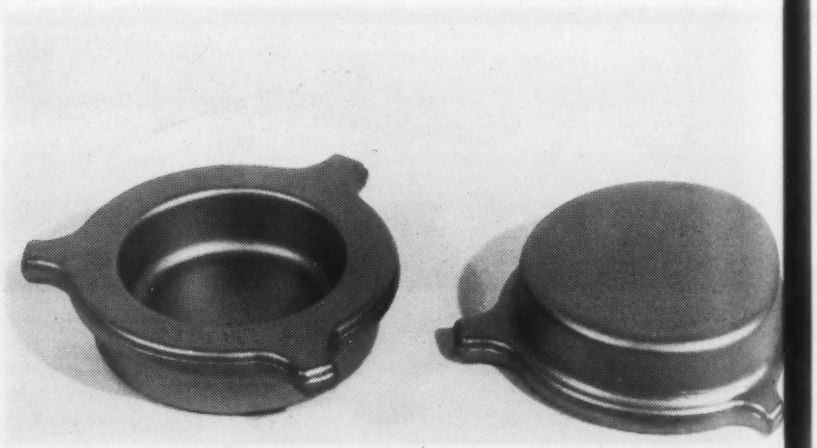


Compressor disk *for turbojet engine, forged from titanium alloy containing 4 manganese and 4% aluminum.*



Compressor rotor blade *for jet engine, forged from titanium alloy containing 2 iron, 2 chromium and 2% molybdenum; it weighs 0.28 lb. Forged in the same dies, 430 stainless blade weighed 0.47 lb.*

Bearing cover *for jet engine, forged from commercial titanium. Titanium is more like aluminum than steel in its resistance to plastic flow.*



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Curtiss-Wright Corp.
Drop Forging Assn.
Dow Chemical Co.
Midvale-Heppenstall Co.
International Nickel Co.
Kaiser Aluminum & Chemical Corp.
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Storms Drop Forging Co.
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FILE FACTS

Diallyl Phthalate Molding Materials — Materials Data Sheet

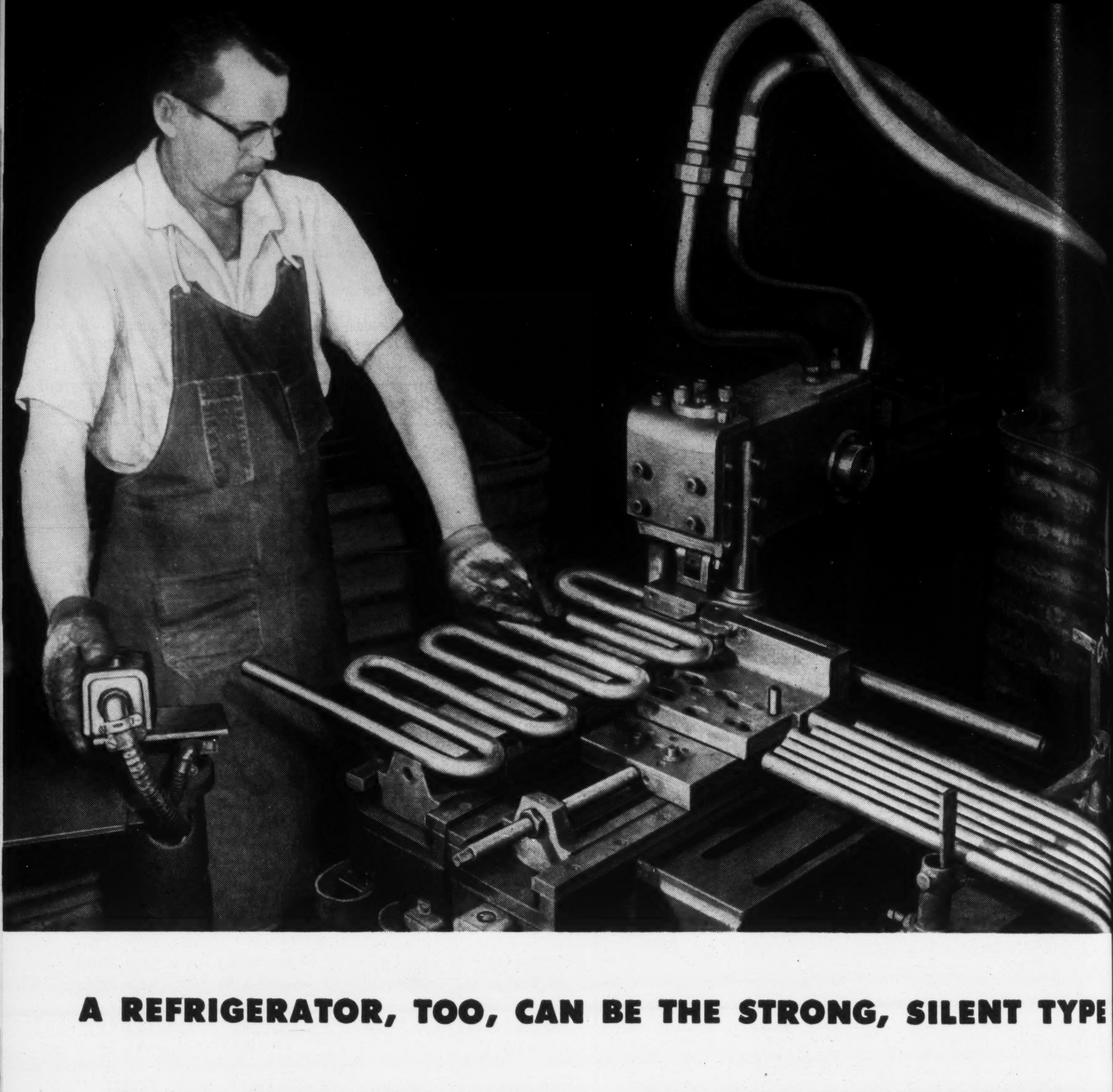
Diallyl phthalate (DAP) thermosetting molding materials are primarily intended for electrical or electronic uses where high arc resistance, low dielectric loss, high dielectric strength and good mechanical properties must be coupled with good retention of these properties after exposure to humidity or moisture. Because of their low mold and post mold shrinkage the materials can be easily molded around large inserts without cracking.

Type	ASTM Test	Orlon-Filled	Dacron-Filled	Asbestos-Filled	Glass Fiber-Filled
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.31-1.34	1.40	1.65-1.70	1.55-1.59
Coef of Ther Exp, per °F	D696	1.5×10^{-5}	2.0×10^{-5}	3.5×10^{-5}	$2.2\text{-}2.6 \times 10^{-5}$
Water Absorption (122 F, 48 hr), %	—	0.2-0.5	0.2	0.4-0.5	0.12-0.2
Flammability (ignition time), sec	—	68	84-90	70	400-450
Heat Distortion Temp, F	D648	240-266	270-290	300-350	300-350
MECHANICAL PROPERTIES					
Mod of Elast in Tension (cond 48 hr at 122 F), psi	D638	6×10^5	—	17×10^5	—
Tensile Strength, psi	D638	4500-6000	4600	4000-5500	5500-7000
Hardness, Rockwell M	D785	108	—	107	100
Impact Strength (Izod notched), ft-lb/in. notch	D256	0.5-1.2	1.7-4.5	0.30-0.45	0.5-6.0
Flexural Strength, 1000 psi	D790	10-10.5	9-11.5	8-10	10-12
Compressive Strength, 1000 psi	D695	20-30	30	18-25	25
ELECTRICAL PROPERTIES					
Dielectric Strength, v/mil	D149	—	—	—	—
Short Time (dry)		366	376-390	378	382-430
Short Time (wet)[a]		375	360-391	330	345-420
Step by Step (dry)		364	350-374	320-350	335-420
Step by Step (wet)[a]		333	350-361	225-250	295-420
Dielectric Breakdown, kv	—				
Short Time (dry)		55.0-81.7	70-80	55-80	63-70
Short Time (wet)[a]		60.0-65.0	66-70	55	45-65
Step by Step (dry)		55.0-60.5	60-65	38-70	60-65
Step by Step (wet)[a]		46.0-60.0	60	39-60	49.5-65
Dissipation Factor (1 kc, 1 mc)	D150				
Dry		0.023, 0.015	0.006, 0.012	0.039, 0.040	0.004, 0.010
Wet		0.026, 0.020	0.009, 0.017	0.042, 0.154	0.008, 0.015
Dielectric Constant (1 kc, 1 mc)	D150				
Dry		3.9, 3.3	3.79, 3.4	5.2, 4.5	4.5, 4.2
Wet		4.1, 3.3	3.8, 3.35	4.8, 4.7	4.6, 4.4
Vol Res (cond 30 days, 100% RH, 158 F), meg-ohm-cm	D257	60,000	100-25,000	6000	1000
Surface Res (cond 30 days, 100% RH, 158 F), megohms	D257	25,000	500-10,000	6000	500
Arc Resistance, sec	D495	85-115	105-125	125-140	125
FABRICATING PROPERTIES					
Bulk Factor	D392	3.5-5.2	5.2	1.9-2.4	1.9-4.0
Compression Molding					
Pressure, psi	—	500-2000	500-2000	500-2000	500-2000
Temperature, F	—	270-320	270-320	270-320	270-320
Transfer Molding					
Pressure, psi	—	1000-5000	1000-5000	1000-5000	1000-5000
Temperature, F	—	270-310	270-310	270-310	270-310
Mold Shrinkage, in./in.	—	0.009	0.010	0.004-0.007	0.004
Post Mold Shrinkage (480 hr, 257 F), in./in.	—	0.001	0.0006	0.0005	0.0005-0.0007
MAX RECOMMENDED SERVICE TEMP, F	—	300	300-370	350-450	400-450
CHEMICAL RESISTANCE	—	Unaffected by weak acids and alkalies and organic solvents. Slightly affected by strong acids and alkalies.			
APPLICABLE MILITARY SPECIFICATIONS	—	MIL-M-18794 Type SD 1-5	MIL-M-18794 Type SD 1-30	MIL-M-14E Type MDG (MIL-P-4389)	MIL-M-18794 Type SDG

[a] Wet = 48 hr. immersion at 125° F.

Prepared from published data of Mesa Plastics Co. and Durez Plastics Div. of Hooker Electrochemical Co.

◄ For more information, Circle No. 566



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TUBULAR PRODUCTS DIVISION

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TA-6074-G

FILE FACTS

Properties of Carbides

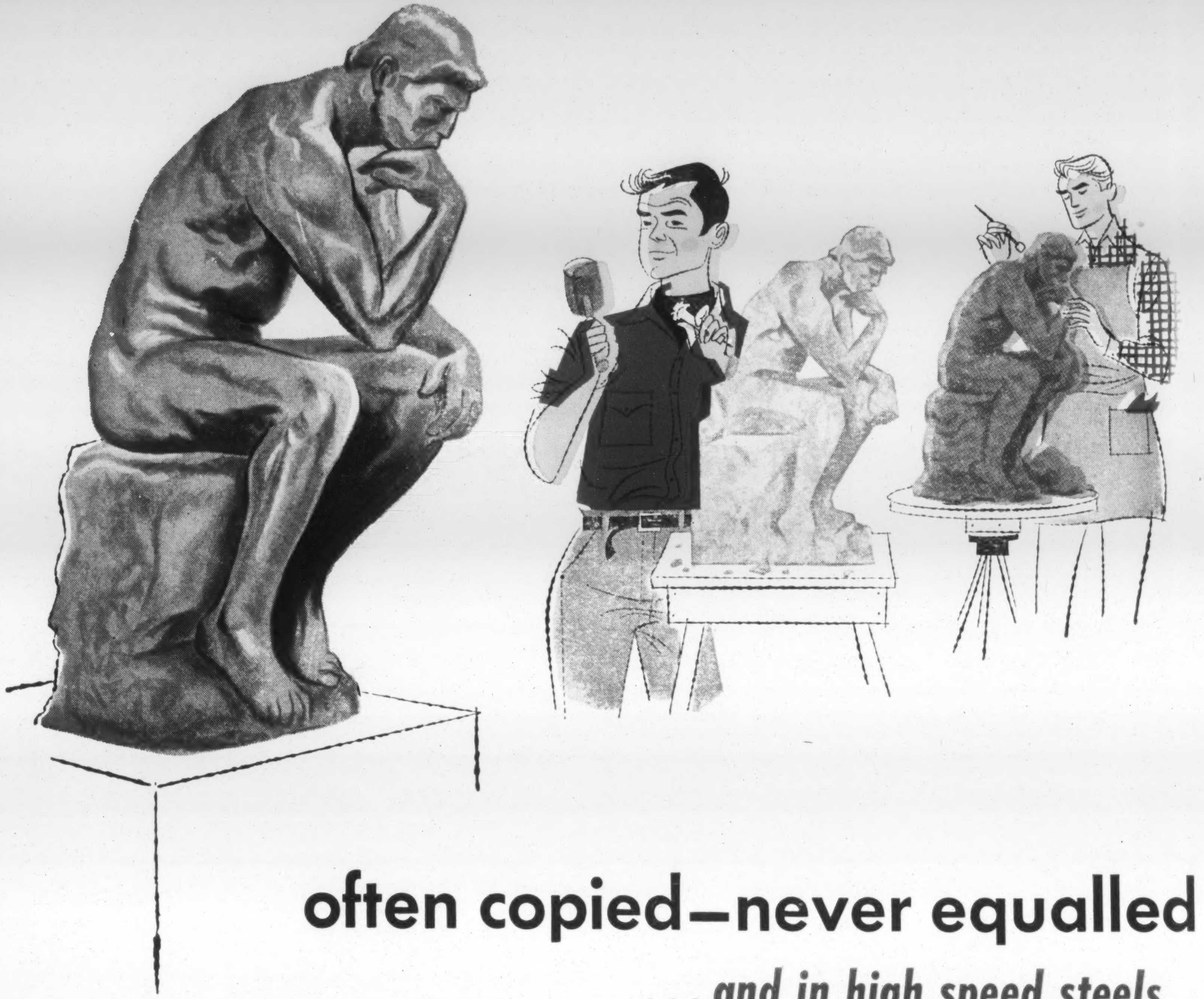
Properties	Beryllium Carbide (Be_2C)	Titanium Carbide (TiC)	Silicon Carbide (SiC)	Columbium Carbide (CbC)	Tantalum Carbide (TaC)
Mohs' Hardness	9+	8-9	9.2	9-10	9+
Elec Resistivity (r.t.), ohm-cm	1.1	1.05×10^{-4}	107-200	7.4×10^{-5}	2×10^{-5}
Ther Cond (68-795 F), Btu/sq ft/hr/°F/in.	145.2	119.0[a]	290.3	98.7[a]	153.9[a]
Coef of Ther Exp (77-1472 F), per °F	5.8×10^{-6}	4.1×10^{-6}	2.6×10^{-6}	—	4.6×10^{-6}
Compressive Strength (r.t.), psi	105,000	109,000	82,000	—	—
Modulus of Rupture (r.t.), psi	16,000	—	4000	—	—
Ther Shock Res (air quenched), no. of cycles at desi_nated temp range	4 at 2000-1470F	—	100 at 2500-77F	—	—
Methods of Fabrication	Hot pressing, steel die pressing and sintering, hydrostatic pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering, extrusion and sintering, slip casting	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering

Properties of Carbides (continued)

Properties	Boron Carbide (B_4C)	Tungsten Carbide ($W_2C^{(\beta)}$)	Tungsten Carbide (WC)	Vanadium Carbide (VC)	Zirconium Carbide (ZrC)
Mohs' Hardness	9.3	9-10	9+	9-10	8-9
Elec Resistivity (r.t.), ohm-cm	0.30-0.80	8.1×10^{-5}	1.2×10^{-5}	1.56×10^{-4}	6.34×10^{-5}
Ther Cond (68-795 F), Btu/sq ft/hr/°F/in	203.2-580.6	—	—	—	142.3[a]
Coef of Ther Exp (77-1472 F), per °F	2.5×10^{-6}	3.3×10^{-6}	3.4×10^{-6}	—	3.7×10^{-6}
Compressive Strength (r.t.), psi	414,000	—	—	89,000	238,000
Modulus of Rupture (r.t.), psi	44,000	—	—	—	—
Ther Shock Res (air quenched), no. of cycles at designated temp range	½ at 1830-86F	—	—	—	—
Methods of Fabrication	Hot pressing, extrusion and sintering	Hot pressing	Hot pressing, steel die pressing and sintering	Hot pressing	Hot pressing, steel die pressing and sintering

[a] Room temperature.

Abstracted from Campbell, I. E., *High Temperature Technology*, John Wiley & Sons, New York, 1956 (sponsored by Electrochemical Society).



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What's new IN MATERIAL

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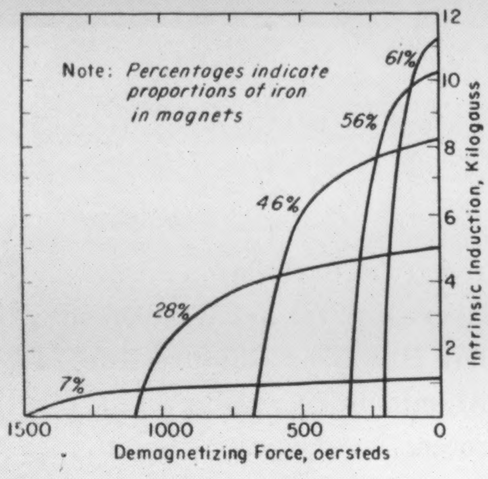
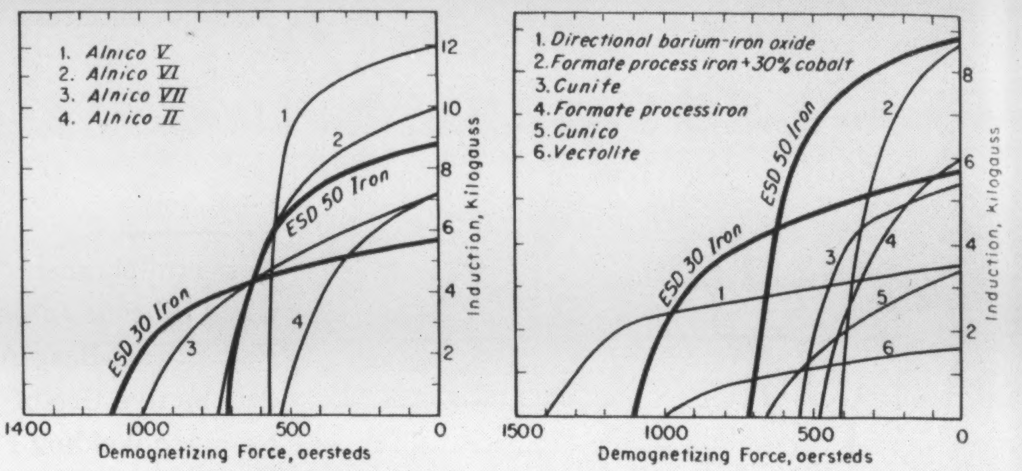


Effect *of iron particle content on demagnetization curves.*



Comparative demagnetization *curves of two iron particle magnets (ESD 30 and 50 Irons) and ten other magnet materials.*

Powerful Magnets from Tiny Particles

■ Elongated iron particles one millionth of an inch thick have been found to possess 100,000 times more resistance to demagnetization than ordinary magnets. This development, announced by General Electric Co., holds particular significance for designers in that it offers almost unlimited possibilities for the design of magnets and electrical equipment utilizing magnets. For one thing, size limitations are practically eliminated; for another, materials selection is made easier because the particles can be embedded in metal, glass, rubber or plastics.

Although iron particle magnets are still in the developmental stage, magnets equal in strength to the strongest commercial magnets have been made. Theoretically, the ultra-small particle magnets can be made "ten times stronger than the best available magnets." The magnets are made by aligning the submicroscopic particles in a powerful magnetic field, then compacting them under great pressure in a suitable binder (metal, glass, rubber or plastics).

Theory of magnetization

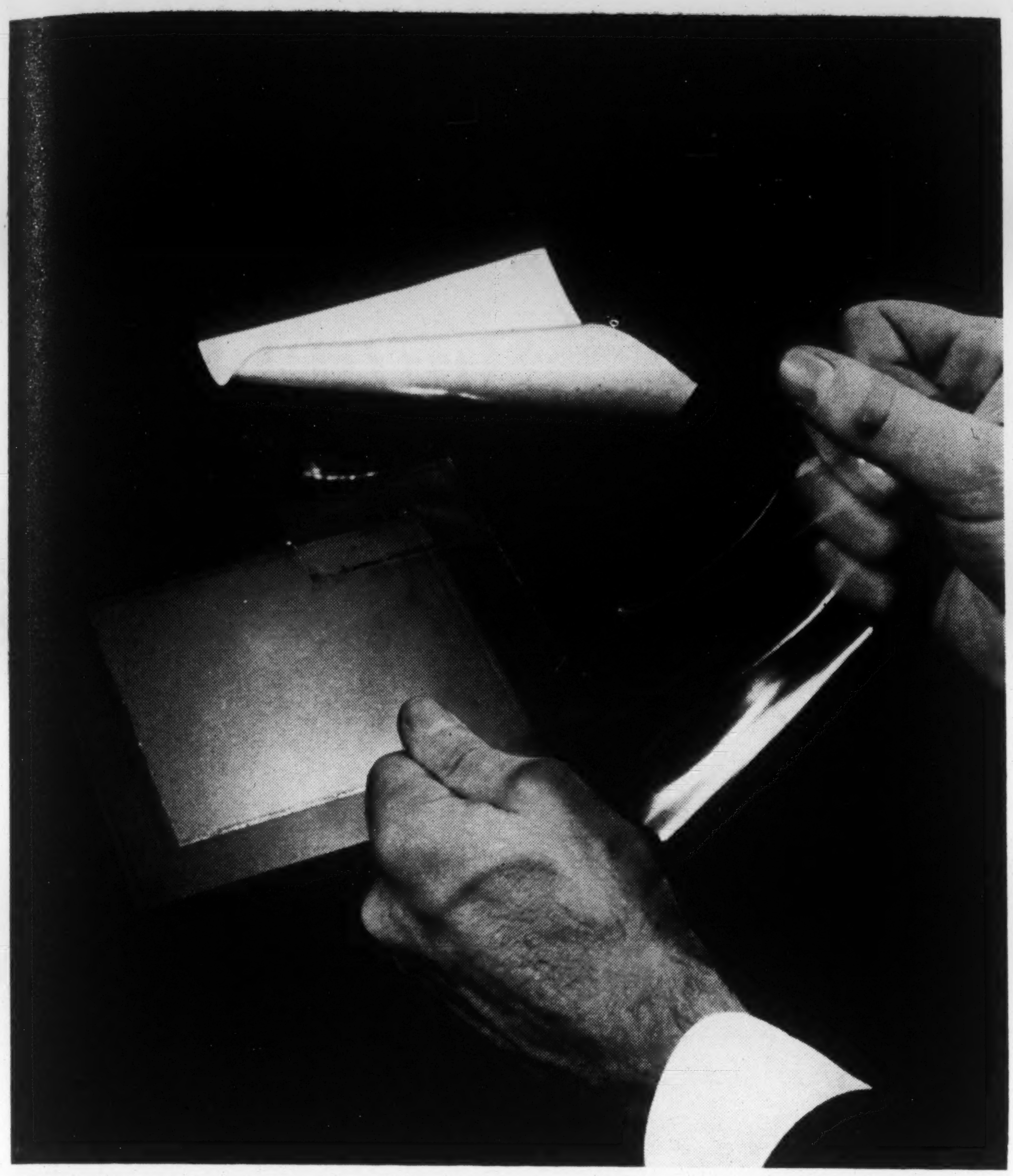
In explaining how the magnets achieve their high resistance to demagnetization, Dr. Thomas O. Paine, leader of the research project, says electrons in atoms not only revolve around the nucleus but also spin on their own axes, creating a magnetic field. In most materials there are as many electrons spinning clockwise as counterclockwise, so that, in effect, the magnetic fields cancel each other. In some elements, iron for example, the balance does not exist. Since there are a significantly greater number of electrons spinning in one direction, there is a net magnetic field associated with each atom.

Magnetic domains

When atoms are brought together to form a solid crystal of iron, the electrons of adjacent atoms interact in such a way that their magnetic fields run parallel, intensifying the effect until there is a magnet. However, these interatomic forces hold the spinning electrons in alignment only in local regions of the crystal, called "magnetic domains." An ordinary piece of iron contains many domains, and when a magnetic field is applied the domains tend to reorient themselves into alignment with the applied field. They do this principally by movement of the boundaries separating the domains. If the domain boundaries can be prevented from moving, the magnet will retain its flux under the strongest demagnetizing fields. This is exactly what GE has accomplished.

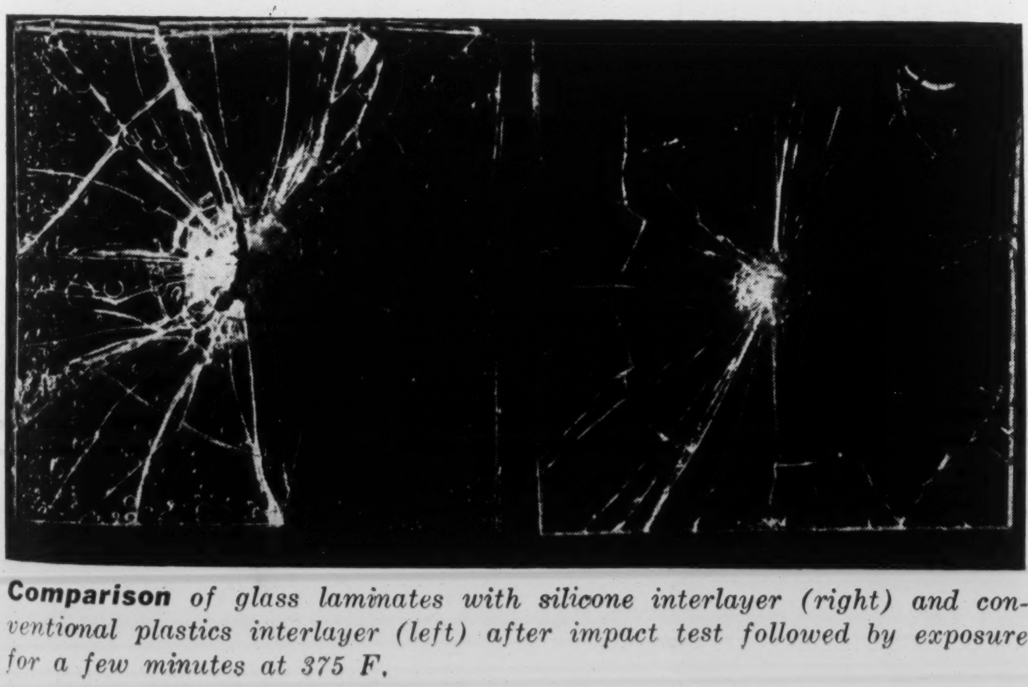
The width of iron domain boundaries is known to be approximately one millionth of an inch. Hence, iron particles of this size contain no boundaries; in effect, they are "single domain" particles. Having no domain boundary to move, a single domain particle theoretically cannot be demagnetized.

Of especial importance in this development is the elimination of cobalt and nickel, both critical materials for military and industrial uses. Elimination of cobalt also makes possible the use of magnets in nuclear reactors.



Elasticity, *transparency and mechanical strength, coupled with high temperature resistance, are features of a new silicone rubber interlayer for aircraft windshields.*

Clear Silicone Interlayers Good for Jet Windshields



Comparison *of glass laminates with silicone interlayer (right) and conventional plastics interlayer (left) after impact test followed by exposure for a few minutes at 375 F.*

■ It has been evident for some time that conventional safety glass interlayers, consisting of plasticized polyvinyl butyral, would not withstand the intense frictional heat generated by supersonic aircraft speeds. As a result, *Dow Corning Corp.*, Midland, Mich., in conjunction with Wright Air Development Center, has developed a new silicone rubber, identified as Silastic Type K Interlayer, intended to serve as a heat resistant center layer in safety glass windshields.

Uncured, the silicone material is a soft, plastic and extremely tacky sheet. It flows readily under pressure, requires no bonding adhesive and forms a tough rubbery interlayer. Laminated and cured under pressure, the silicone material has excellent optical properties. According to the producer, the new rubber is truly transparent, and haze and distortion are greatly minimized.

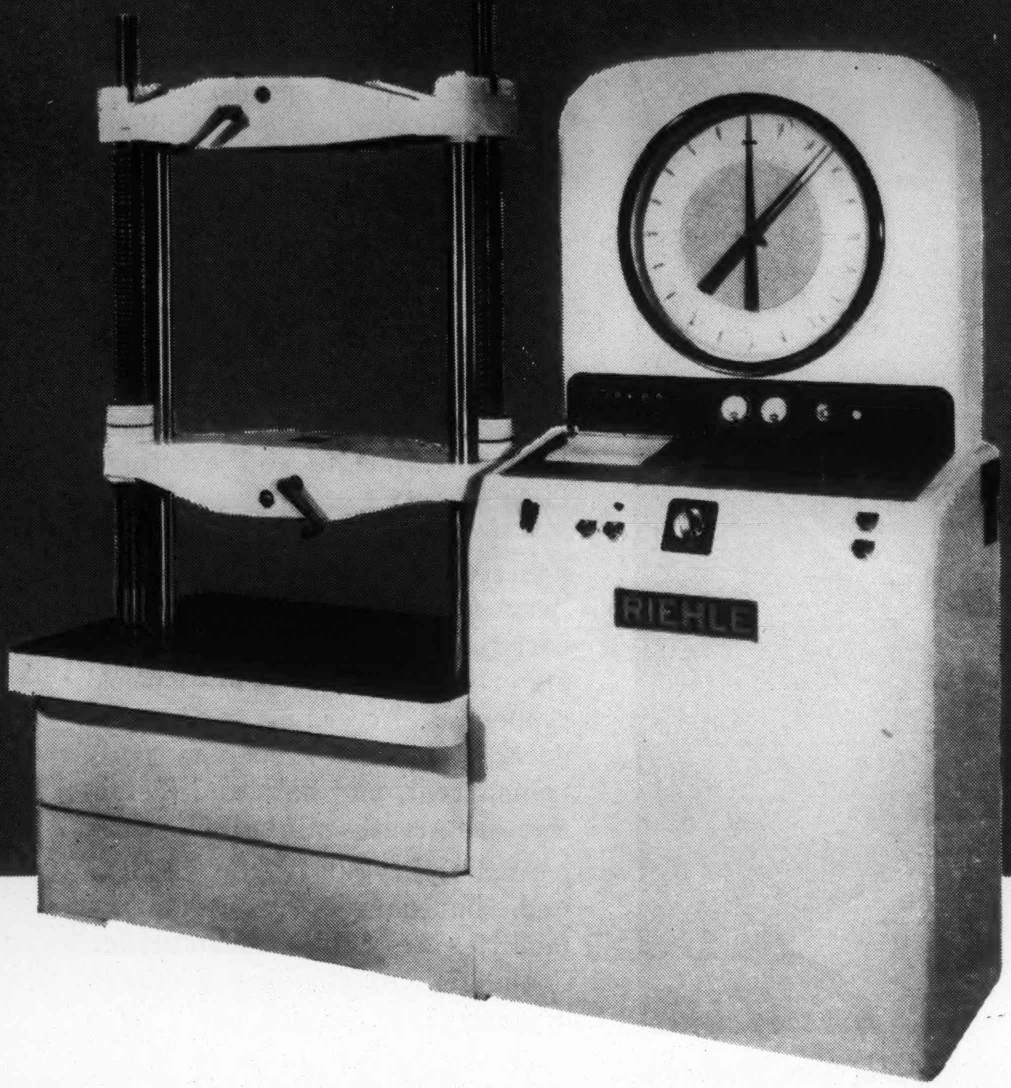
Availability at present is limited, but larger manufacturing facilities are under construction. Completion of the new facilities in early 1957 should see a drop from the current price of \$15.35 per sq ft of 25-mil sheeting.

Conventional interlayers soften, evolve gas bubbles and rapidly lose shear strength at temperatures above 180 F (see comparison photo). At temperatures in the range of —65 F, conventional interlayers are almost as brittle as glass itself. At either temperature extreme, conventional interlayer material is unable to prevent cracked glass from shattering.

Windshields made with the new silicone rubber interlayer, on the other hand, are said to retain full strength and clarity at temperatures ranging from —65 to over 350 F. They have somewhat less shatter resistance at temperatures up to 160 F than conventional laminates, but strength of the conventional interlayer falls off so sharply above 160 F that at 200 F the new silicone is more than twice as strong.

(more What's New on p 165)

NOW... two more reasons for retiring inadequate testing machines



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Here are the *sensitivity* and *rapid response* plus complete instrumentation you need for testing at elevated temperatures as well as at room temperatures.

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Riehle's new sensitivity and rapid response assure you of that flexibility and precision you must now have. The new Electro-Balanced Indicating Unit is available for both hydraulic and screw power testing machines — by Riehle.

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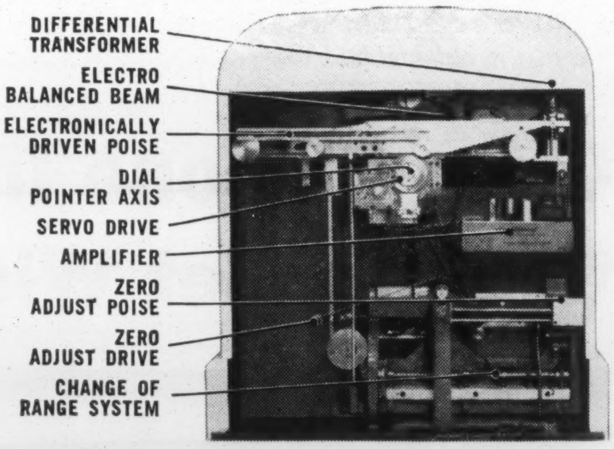
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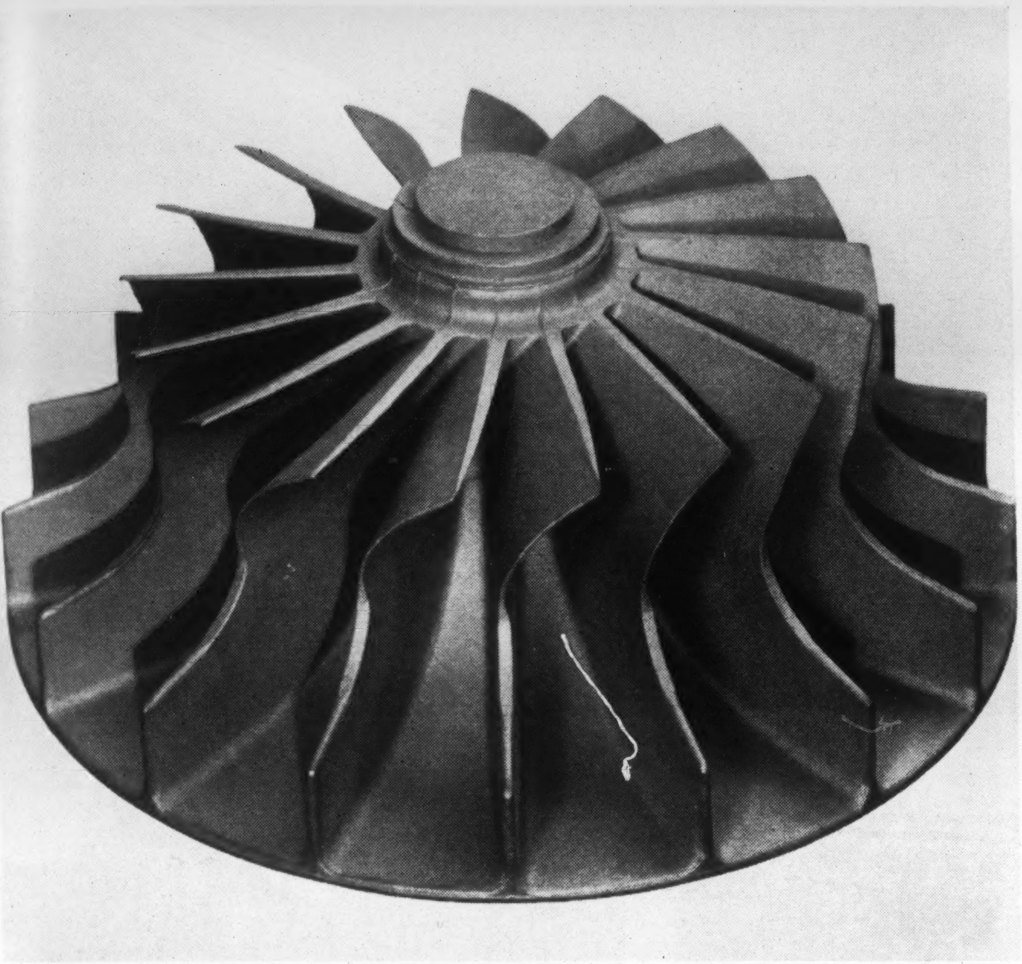
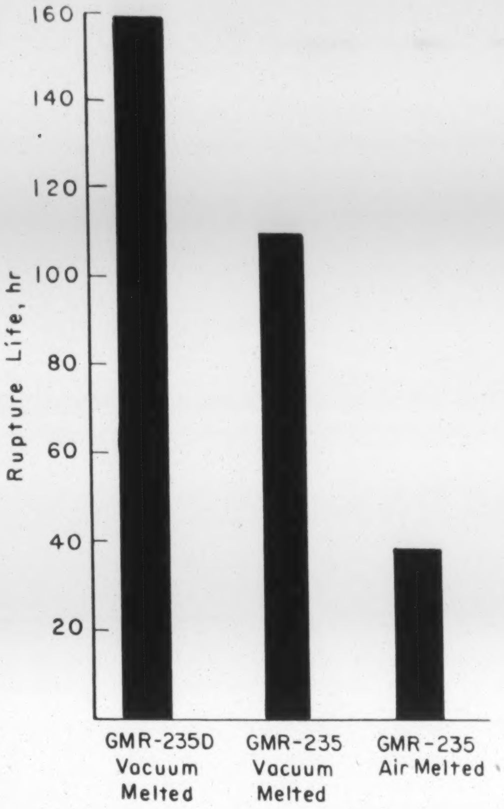


Experimental turbine wheel *of GMR-235 integrally cast by investment casting process.*



Comparative rupture life *at 1600 F and 28,000 psi of three different versions of GMR-235.*

RUPTURE DATA FOR AS-CAST GMR-235

Temperature, F	Avg Stress, 1000 psi		
	10 Hr	50 Hr	100 Hr
1500	48	40	37
1650	29	23	21
1800	13	10	9

New Nickel-Base Alloy Has Long Rupture Life

■ Limited data are now available on GMR-235, a nickel-base, high temperature alloy developed by General Motors research staff and first announced two years ago. In addition to nickel, the alloy contains chromium, molybdenum, iron and boron, with aluminum and titanium as hardening agents. It is produced by air and vacuum melting techniques. *Haynes Stellite Co.*, 420 Lexington Ave., New York, has been licensed to produce and sell the new alloy.

Properties

The relatively high percentages of aluminum (3%) and titanium (2%), combined with minute quantities of boron (.06%), have resulted in a cast alloy with high temperature strength, adequate ductility and low strategic alloy content. It also shows good resistance to overaging at service temperatures, retaining much of its strength for periods over 1000 hr.

The air melted version of the alloy is capable of a minimum rupture life of 75 hr at 35,000 psi and 1500 F, with a minimum elongation at rupture of 5%. Vacuum melted GMR-235 is capable of meeting a minimum rupture life of 60 hr at 28,000 psi

SHORT TIME TENSILE PROPERTIES OF GMR-235 [a]

Temperature, F	Tensile Strength, 1000 psi	Elongation, %
Room[b]	102 110	7 12
1000	102 113	9 10
1200	109 102	10 8
1350	111 88	9 15
1500	89 55	16 14
1650	56 25	25 24
1800	33	25

[a] Data given for two tests at each elevated temperature.

[b] Yield strength at 0.20% offset is 89,400 psi at room temperature.

SHARON FORGING INGOTS
17

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and 1600 F, with a minimum elongation at rupture of 10%.

Welding of the alloy is currently being investigated. Preliminary results indicate that boron is responsible for some welding difficulties. In heat treating the alloy at temperatures above 1600 F, GM researchers recommend a protective atmosphere such as argon or helium. The alloy can be ground with proper feeds, speeds and grinding wheel abrasives.

Designed for use in gas turbine and jet engine parts, the alloy is presently being evaluated in General Motors' experimental turbine-powered automobile, the "Firebird."

Modified version

Recently a modification of GMR-235, called GMR-235D, has been developed by GM and licensed to Haynes Stellite. Produced only by vacuum melting at present, the new version contains 3.00 to 3.75% aluminum, 1.75 to 2.75% titanium and 0.05 to 0.10% boron. It is capable of meeting a specification calling for 120 hr minimum life at 28,000 psi and 1600 F, with a minimum elongation at rupture of 8%.

COMPOSITION OF GMR-235, %

Carbon	0.10–0.20
Manganese	0.25 max
Silicon	0.60 max
Chromium	14.00–17.00
Iron	8.00–12.00
Molybdenum	4.50– 6.00
Aluminum	2.50– 3.50
Titanium	1.50– 2.50
Boron	0.025–0.100
Nickel	Balance

Moldable Irradiated Polyethylene?

It may be available before too long

■ Reports from the laboratory indicate that a breakthrough in development and use of irradiated polyethylene may be forthcoming in the not-too-distant future. The development is in the form of a preirradiated polyethylene extrusion material.

Irradiated polyethylene was announced back in 1954 (see M&M, Sept '54, p 91) and improvements in the material occurred shortly thereafter (see M&M, Feb '55, p 104). But except for film and tape, a big stumbling block to its use was its infusibility; the polyethylene had to be formed prior to irradiation, raising the cost of products and limiting size and shape of parts. The availability of a polyethylene compound, already irradiated, that can then be extruded or molded would offer advantages in design and economy.

In the last few months General Electric Co. has twice made reference to a preirradiated extrusion grade of polyethylene, Irrathene E-234, which has been available in very limited experimental quantities. The obvious reason for the reluctance to discuss it publicly is the mass of requests for information and samples that would result and which would be impossible to fill at present.

Though only limited property data are available, indications are that the amount of irradiation is not as great as that employed for film and molded parts. Thus, the degree of improvement in temperature resistance is not the same as that obtained by irradiation after forming. However, as the accompanying table shows, the material has excellent resistance to stress cracking. It also has the same high dielectric properties as regular polyethylene, coupled with the high temperature aging resistance characteristic of irradiated polyethylene.

An important potential use for E-234 is wire insulation. Experimental work indicates the material can be extruded onto wire in the same fashion as regular polyethylene with only slight modifications of conditions.

To date, no reports are available as to the material's suitability for forming by other techniques. Unofficial comments indicate that compression molding might offer the most satisfactory method of producing molded parts. So far injection molding has met with little success, due to the development of intolerable residual internal stresses.

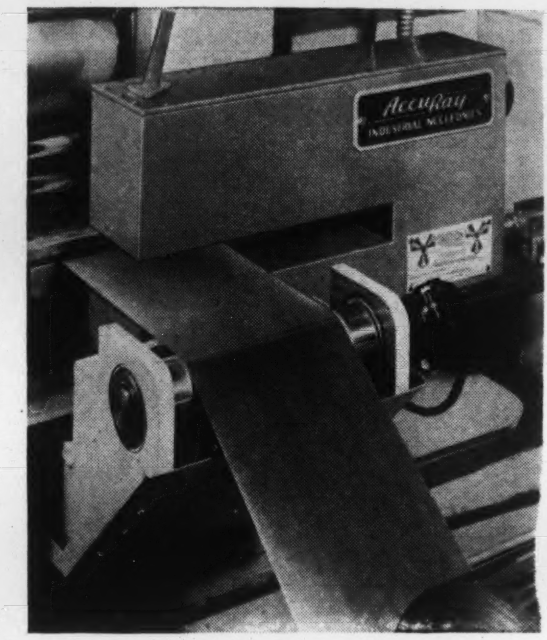
(more What's New on p 168)

PROPERTIES OF PREIRRADIATED POLYETHYLENE

Specific Gravity	0.92
Water Absorption	Negligible
Flammability	Slow burning
Dielectric Constant (60 cycles to 10,000 mc)	2.3
Power Factor (60 cycles to 10,000 mc)	0.0005
Insulation Resistance (0.030 in. wall on No. 16 AWG, tinned, stranded wire), megohms	10^6
Stress Cracking Resistance	No failures in Bell Laboratories' test in acetic acid or Igepal at 170 F for 60 days

MONEL • NICKEL • COPPER • ALLOYS
THIN STRIP

UNIFORM
AS THE ATOM



Somers Thin Strip now Gauged by Nuclear Energy

To meet the increasing demands of electronics and other industries for *uniform* closer tolerances, Somers Brass has taken advantage of one of the latest developments in the electronic field by installing the first Accu-Ray gauges in the non-ferrous industry. These units make it possible to check and control thickness from edge to edge throughout each coil to a degree of accuracy never before known.

Accu-Ray gauging is typical of the modern methods Somers combines with engineering experience to provide thin strip metal to your most rigid specifications. Nickel, Monel, and Nickel Alloys from .020″ to .00075″. Brass, Bronze, Copper and Alloys from .010″ to .00075″.

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More than 100 lb *of aluminum are used in this 1957 Chrysler car.*

Automotive Use of Aluminum Increasing, Especially in Trim

Total consumption of aluminum in 1957 passenger cars should approximate 247,500,000 lb, according to Aluminum Co. of America. This is based on two assumptions: 1) the auto industry's forecast of 6,500,000 cars and 2) a 10% increase in the amount of aluminum used in each car. Over-all the figure represents 23% more aluminum than was actually used in 1956 automobiles. Actual average poundage per car is estimated at 38.1 for 1957, as compared to 34.6 for 1956 and 29.6 for 1955.

By far the largest percentage increase last year was made by aluminum trim. Harry L. Smith, Alcoa vice president, says that such uses now account for 13.2% of the total aluminum content of 1957 cars—an 80% gain over 1956 trim applications. The largest single aluminum application in passenger vehicles is automatic transmissions, now utilizing 41.1%.

Mr. Smith predicts that 1958 passenger cars will show a greater increase in the use of aluminum than in "any one year during the past two decades." The aluminum fin, brass tube radiator now being road tested in several car models, he believes, "may well constitute the next major use of the metal in automobiles."

New Arc Welding Process

A new semiautomatic metal arc welding process is said to combine the versatility of electrode welding with the high deposition rates of submerged arc welding. Called Unionarc welding, the new process employs a continuously fed wire electrode which is mag-

★ some of the more than 100 places where ENJAY BUTYL works, silently and dependably, helping to improve the performance of today's new cars.

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Readily available in non-staining grades, Enjay Butyl rubber can be compounded into white and light-colored parts that combine beauty with top-notch performance. Low in cost, it out-performs and out-lasts all other rubbers formerly used, and may well be able to *cut costs* and *improve performance* in *your* product. For further information, and for expert technical assistance, contact the Enjay Company.

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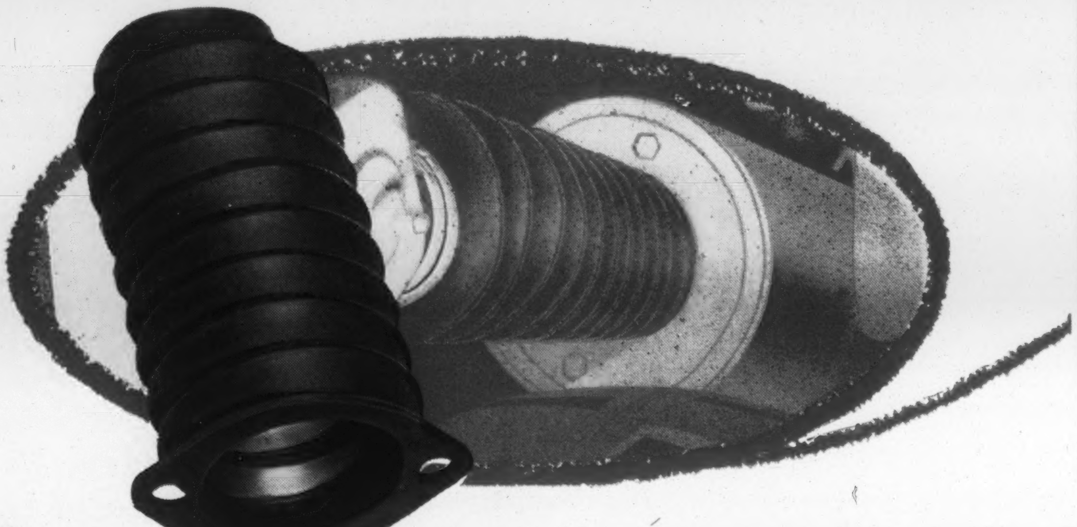
THE SHAPE OF THINGS IN MOLDED RUBBER

MOLDED BOOT MINUS STOCKINGS
CUTS COST FOR LIFT TRUCK MANUFACTURER



APPLICATION:
Protective boot for hydraulic lift and tilt mechanism on gasoline powered lift truck.

PROBLEM:
This manufacturer's print specified a molded boot with stockinette base. Boot had to have good sunlight resistance; resistance to hydraulic oils, automotive greases and dirt; also, it had to maintain good flexing characteristics without checking or cracking.

SOLUTION:
Acushnet engineers and lab chemists were successful in eliminating the use of stockinette as a base for the rubber covering. The boot was compression molded entirely of an APCO neoprene compound which met all specifications. To effect further cost reductions, the flange area and holes were died out, permitting a choice of round or diagonal shaped mounting area. This resulted in a saving in mold cost and produced a cleaner, more precise part.

Designing a new molded rubber or silicone part? Immediate technical assistance now available from Acushnet in part design, custom compounding and molding techniques can effect substantial savings in production costs.

Send for Acushnet "Rubber Data Handbook."

What's Your Shape?

Acushnet

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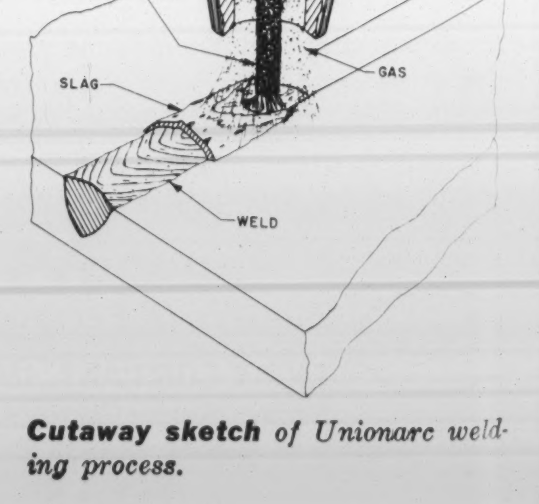
netically coated with flux and is shielded in a gas atmosphere.

In operation, the flux is carried to the welding nozzle by a carbon dioxide gas stream and surrounds the welding wire as it is fed from the contact tip of the torch. When welding current is flowing, a magnetic field is established around the extended portion of the welding wire. The flux is attracted toward the exposed wire and coats it. As the wire is directed into the weld puddle, the flux melts, refining the weld metal and shielding it from atmospheric contamination. The carbon dioxide flowing from the torch nozzle also helps to shield the molten metal and the arc. The open arc characteristic of Unionarc welding permits excellent visibility of the weld zone, thereby allowing welds to be made manually in flat, horizontal, vertical or overhead positions.

Developed by Linde Air Products Co., Div. of Union Carbide and Carbon Corp., the new process can be used to weld across gaps and along seams containing moderate amounts of rust, scale and moisture without affecting



Cutaway sketch *of Unionarc welding process.*

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Windsor Felts are unique, fiber bonded, non-woven structures, engineered to serve as economical and efficient filter media for industrial processing. Quick facts:

- **Greater product recovery**
- **Easy cake release**
- **Can be hosed off without taking from press**
- **Can be re-used indefinitely**
- **Produce less plugging**
- **Do not shrink, are ravel-free and produce clean-cut edges**
- **Reduce leakage**
- **Have unusual stability**
- **Temperatures to 250F**

These outstanding properties make Windsor Felts highly suitable for use on plate and frame, pressure leaf, rotary vacuum, cartridge or specialty filters.

The Engineering and Research Division invites your inquiry and will be pleased to work with you on your specific filtration problem and make recommendations.

For the newest in economical filter material send for Data Sheet #18 WINDSOR FELT-LIQUID FILTRATION, making request on your firm's letterhead.

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American Felt Company

American Felt Company

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WARHEADS* THAT EXPLODED AN OLD THEORY....

...that all castings had to be big, thick and sometimes cumbersome... had to undergo heavy machining and finishing to even approach accuracy of specfication.

Not so today! The Warheads* are another interesting example of how Albion's resin *shell casting* process has eliminated much of the casting-finishing cost...and, permitted broader utilization of ferritic and pearlitic malleable irons.

As an example, both the castings above appear to be the same *on the outside*...and both are of the same material. Yet, one is far lighter, thinner-walled and accurate... requiring far less machining, finishing time. Another positive proof that Albion's *resin shell* casting process permits closer tolerances, less excess metal—resulting in savings from the laboratory through finishing.

Albion's ferritic and pearlitic malleable irons can be cast to your exacting specifications with physical properties to suit your needs.

Make malleable iron, the versatile metal, a part of your product. Contact your Albion Malleable Iron Company representative today; he will be glad to bring you up-to-date on the rapid development in casting techniques and advantages that can be yours for the asking.

● *Need design or engineering assistance? Albion's competent staff as well as their Research and Development Laboratory are always at your service.*

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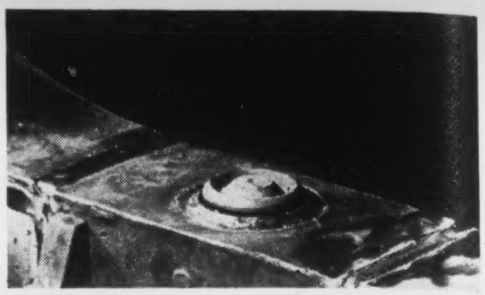


Flat welds *of this casting to a "C" frame assembly show quality of welds possible with new process.*

weld soundness. At present, 3/32-in. and 3/64-in. dia welding wires are used, with welding current usually between 350-450 amps and 125-250 amps, respectively. The company says the new process offers greater simplicity, greater speed and lower costs.

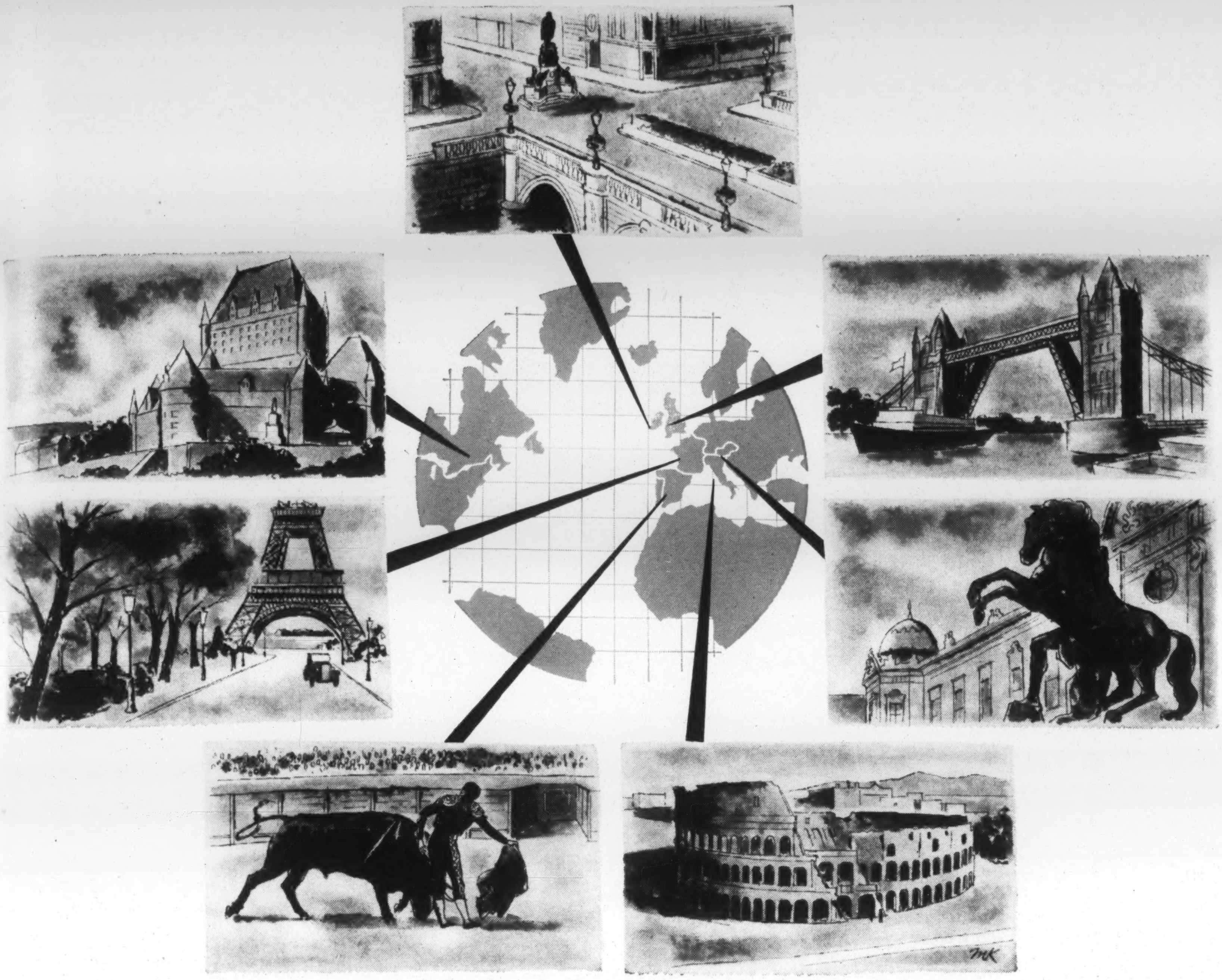
How Environment Affects Creep-Rupture

Both the rupture life and the minimum creep rate of commercial high temperature alloys are affected by environment, a recent investigation shows.

The effect of various atmospheres — air, oxygen, nitrogen, helium and a vacuum—on creep and rupture properties was reported by Paul Shahinian of the Naval Research Laboratory at the 1956 Convention of the American Society for Metals. Alloys investigated were DM 45 low alloy steel, 12% chromium-vanadium steel, Type 204 austenitic stainless steel, N-155, S-816 cobalt-base alloy and Inconel X.

Creep-rupture tests were conducted on both unnotched and notched specimens for durations up to 500 hr at temperatures ranging from 1100 F for low alloy steel to 1500 F for the superalloys. In addition, sections of fractured specimens were examined metallographically, checked for variations in hardness, and analyzed for gas contents. The results show that:

1. Rupture life is longer in air than in any of the other atmos-



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Whenever you buy Nichrome, you are assured of the unsurpassed and unvarying *quality* which has made Nichrome the supreme world standard for electrical-resistance and heat-resistant alloys. This uniformly high quality, which we jealously guard as our most priceless possession, results from the technical excellence, the productive skill, and the quality controls the Driver-Harris craftsmen have gained in over 50 years of experience—and which are maintained with equal rigor in all Driver-Harris plants here and abroad. The result is a continuous benefit to the entire electrical, electronic, and heat-treating industries.

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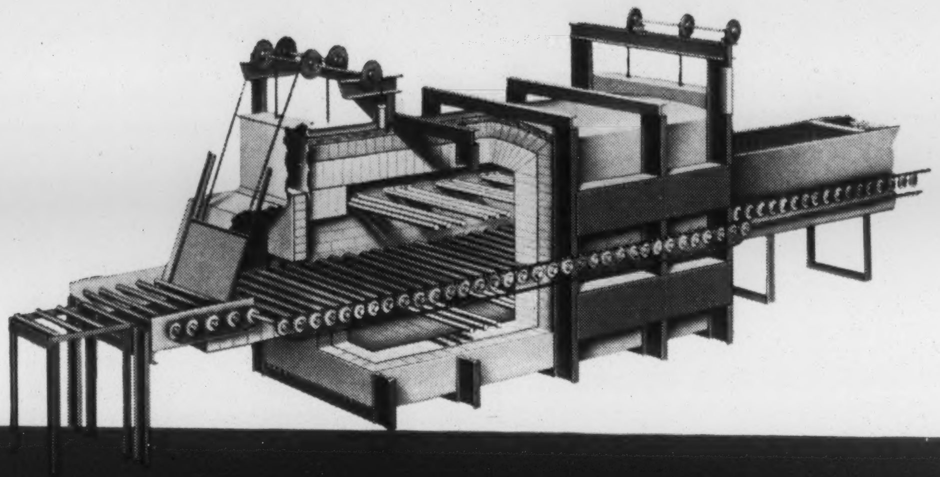
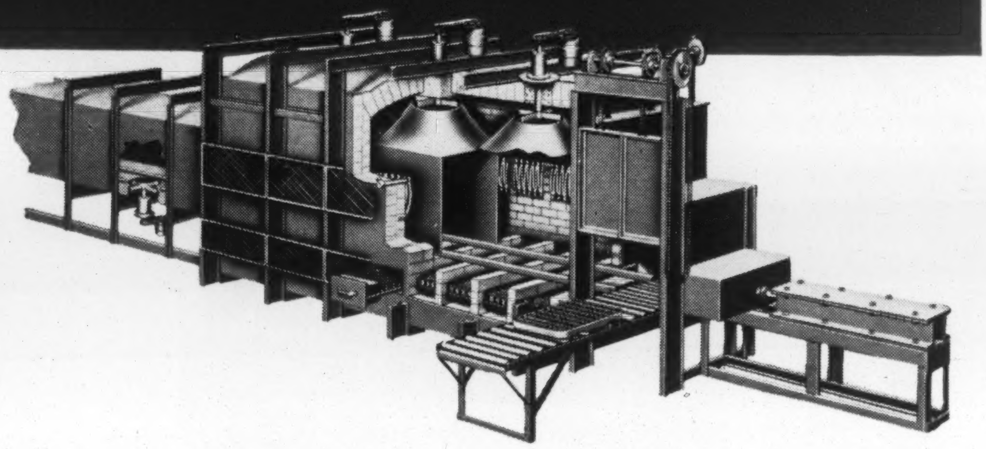
BLAZING THE HEAT TREAT TRAIL WITH HOLCROFT



LET'S TALK ABOUT

the economy of electric heating



Low initial cost—simplified maintenance—efficient use of heat.

All these represent good reasons why electric heat treat furnaces are important considerations. For example, gas-fired and electrically-heated furnaces are frequently competitive; in fact, when total installation cost figures are considered, electric furnaces often have the price advantage.

Upkeep is reasonable, too, because properly designed and installed electric heating elements are so easy to maintain and adjust. Elements are quickly removed for repairs.

Electric heat is more efficiently used for applications in the high temperature range. There is a considerably smaller heat loss in the use of electricity than gas—shrinking the price spread between the two. To be specific, a thorough study must be made of all factors: local power and fuel costs, production demands, quality control standards, etc., before any final decision can be made of the type of heating to be used. Holcroft will help you—a good place to start is to send for our new book **Holcroft and the Electric Furnace.** It's yours without obligation.

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pheres. In general, oxidizing atmospheres resulted in longer rupture lives than the inert atmospheres.

2. Minimum creep rate was generally the lowest for the alloys in air; there was no consistent effect produced by the other atmospheres.

3. The presence of a notch in the alloys of relatively low ductility, S-816 and Inconel X, greatly increases the susceptibility of the materials to the influence of environment.

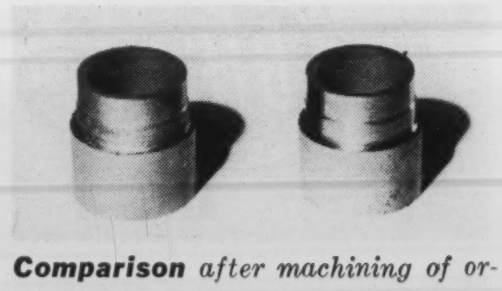
4. The notch sensitivity of a material may be affected by environment. Inconel X at 1500 F and 25,000 psi was notch strengthened in air and oxygen, but weakened in nitrogen and vacuum.

The author suggests several mechanisms by which the presence of oxygen may improve creep-rupture properties, and he points out that the greater atmosphere sensitivity of notched over unnotched specimens indicates that oxidation may tend to blunt cracks.

Iron Powder Parts with Smooth Surfaces

Bound Brook Oil-Less Bearing Co., Bound Brook, N. J., has announced the development of a pure sintered iron material, called Powdiron FM, that combines excellent machining properties and good ductility with low cost.

The company claims that its Powdiron FM parts, after machining, are clean and smooth with a mirrorlike surface, where-



Comparison *after machining of ordinary iron powder part (left) and iron powder part made with new material (right).*

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4 densities in strips or sheets to meet your exact needs

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Dutch Brand offers you a complete line of natural or neoprene chemically blown industrial sponge rubber—in four densities ranging from soft to firm (meets ASTM specifications). Two types of adhesive: pressure-sensitive or dry type. Thicknesses from 1/16″ to 1″—in strips, sheets or special die cuts. For your sponge rubber needs consult Dutch Brand.

Write for this free sample folder . . .

Gives ASTM data, suggested uses and samples of sponge rubber in each density.

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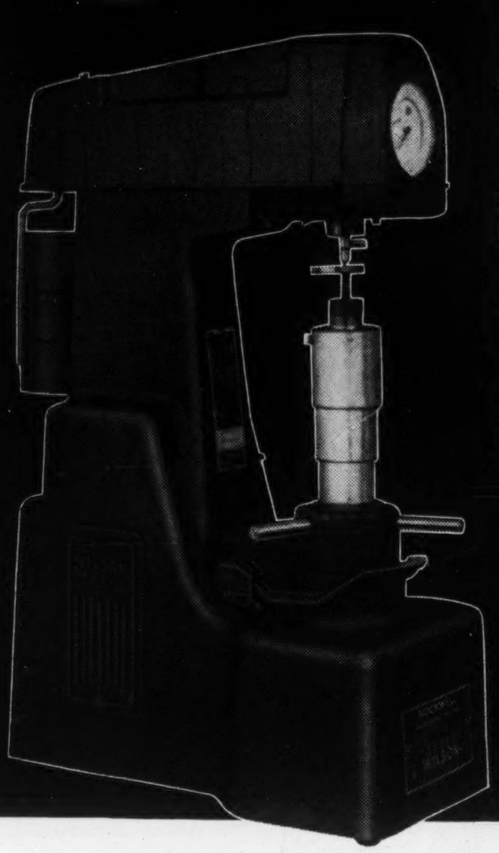

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as ordinary sintered iron parts tend to be ragged, rough-surfaced and chewed up after machining. The new iron parts permit faster machining and are said to triple the tool life possible with ordinary sintered iron, including iron-copper. Previously copper was added to the iron powder to give a better machining part; however, copper increased the cost of the parts.

Epoxy Foam Blocks

Fine textured, easily machined, dimensionally stable prefoamed blocks of epoxy resin measuring 1 x 2 x 6 ft are now available from *D & R Pilot Plants, Inc.*, Hazardville, Conn. The blocks are available in densities from 5 to 20 lb per cu ft and are said to have compressive strengths of from 50 psi at the lower densities to about 1000 psi at the higher densities. The epoxy blocks withstand high temperatures and active solvents and, according to the producer, should find use in tool shops for making check fixtures, templates and models.

Copper-Brazed Joints: Why They Are Strong

The high strength of a copper-brazed steel joint may be attributed to a combination of the greater work hardening capacity of the thin braze metal under restraint and the increase in strength of the copper metal due to alloying with iron.

This is the conclusion reached by R. C. Grassi, I. Cornet and R. S. Berger as a result of an attempt to determine why copper-brazed steel joints produce shear strengths greater than that of the copper used. The investigators examined several existing theories as well as conducted new tests. Their reports appeared in the

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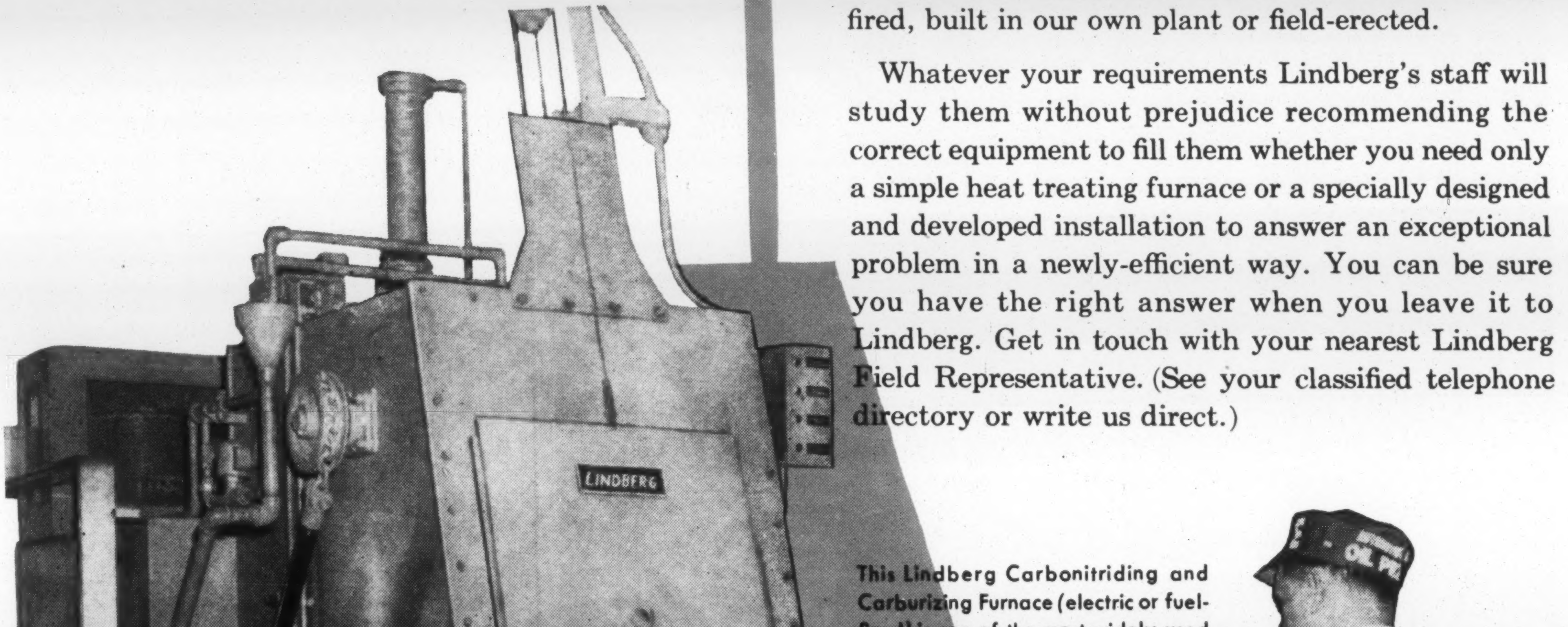

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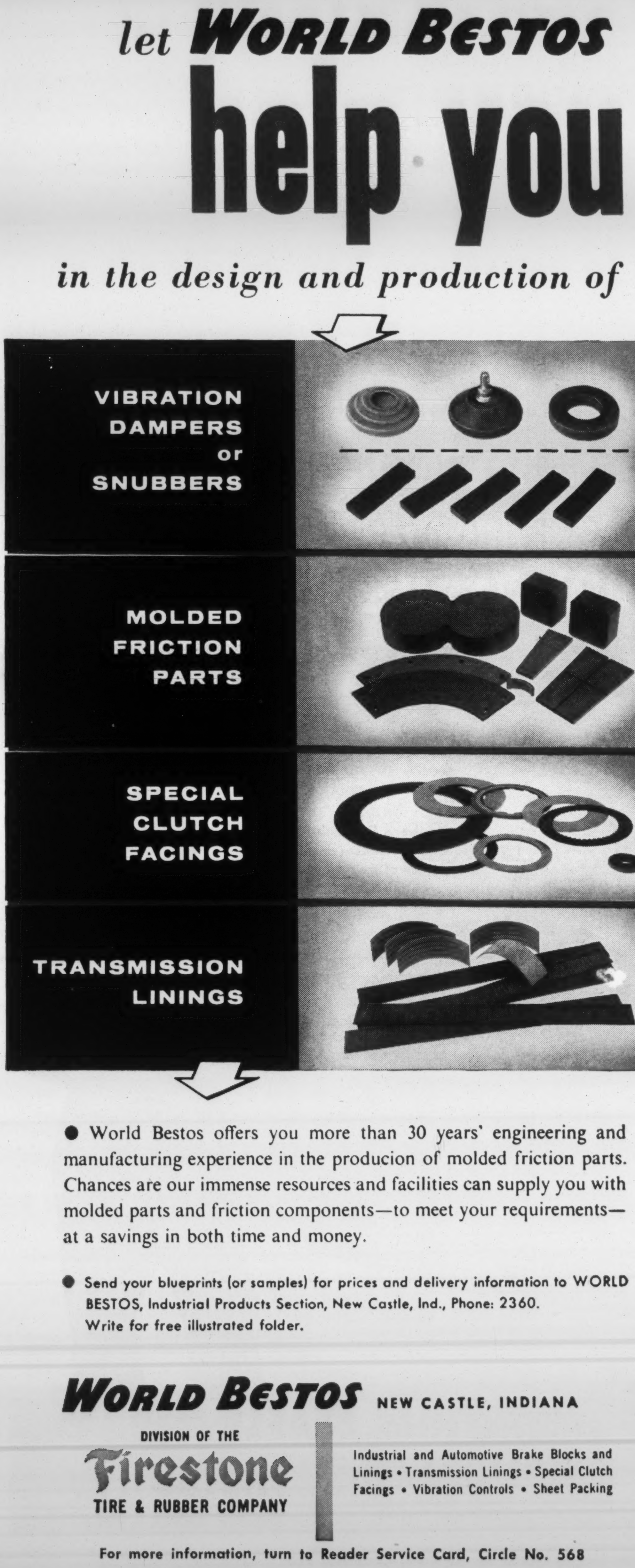

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July '56 issue of *Mechanical Engineering*. Other conclusions were:

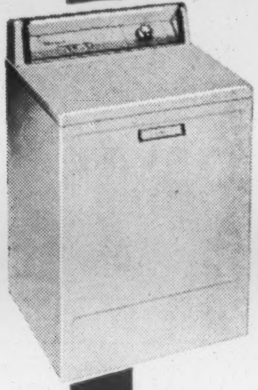
1. Shear strength of a steel joint when brazed with copper is approximately 33,000 psi as compared to 17,000 for silver. Although silver has properties quite similar to those of copper, silver will melt and flow on the surface of steel but will not alloy with steel as copper does.
2. Shear strength of a copper-brazed steel joint depends to a large extent upon design.
3. Initial grain size has negligible effect on shear strength of a copper-brazed steel joint. Average shear strengths were found to be approximately the same for specimens of both fine and coarse initial grain size.
4. For joints brazed with copper or silver, there is no significant variation in the strength of joints with change of ASA class of fit from 1 to 5, inclusive.

Plain carbon steels (SAE 1018, 1020 and 1040) were used in the investigation, and both pure copper and silver were used as brazing metals. All specimens were brazed at a furnace temperature of 2000 F.

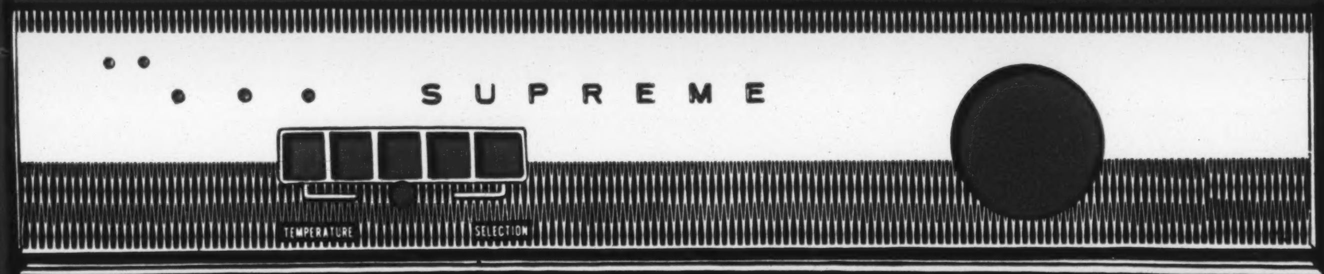
Silicone-Glass Used for Connector Plugs

Connector plugs made of a glass-filled silicone compound show outstanding insulation properties compared to plugs made of Orlon-filled diallyl phthalate, glass-reinforced alkyd and mineral-filled melamine plastics (see graph), according to a recent report from Dow Corning Corp.

The graph is based on tests run on four miniature 26-contact connectors molded by Continental Connector Corp., Long Island City, N. Y. After 240 hr at 96% R.H. and 74 F, the difference between the electrical resistance of silicone-glass connectors and that of other plastics was quite broad. According to Dow Corning, the



HOW RCA Whirlpool TURNED AN IDEA INTO A PRODUCTION REALITY



RCA Whirlpool selected a combination of our processes to produce this beautiful eye-catching escutcheon plate of golden anodized aluminum. The sharply etched design (done by ETCHRITE) is highlighted with white enamel. Deep dimensional embossing (EMBOS) accentuates the word "Supreme". It is our privilege to have worked with RCA Whirlpool designers and engineers on this and other metal trim parts.

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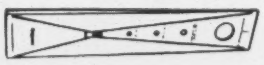

Hotpoint TV escutcheon by
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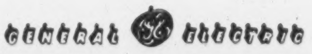
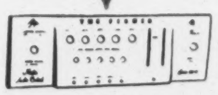
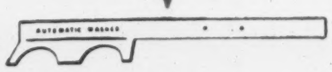


G. E. initials and insignia by
Kolfor



Fisher Panel by
Etchrite



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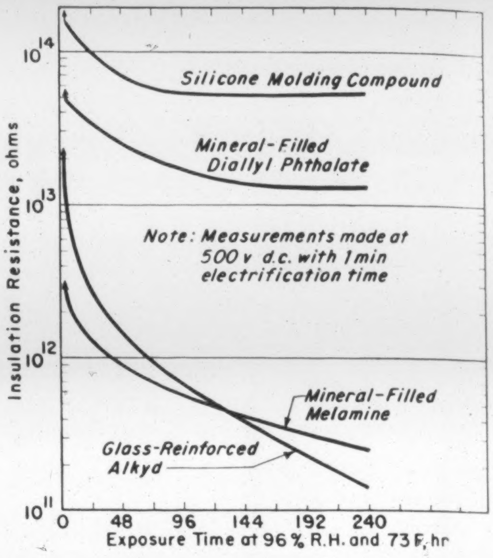

***Insulation resistance** of miniature connector plugs made of silicone-glass and other materials.*

difference would be even more marked at elevated temperatures.

The silicone-glass compound is produced by Dow Corning and called 301 Molding Compound. Composed of fibrous glass strands impregnated with silicone resin, it is supplied in ready-to-use fibers measuring approximately ⅞ in. in length (M&M, Jan '55, p 141).

Approved under specification MIL-M-14E, Grade MSI-30, type 301 silicone units are currently being tested in guided missiles, industrial oven and kitchen ranges.

Self-Locking Nuts Use Nylon Inserts

Self-locking threaded bolts containing a nylon pellet are claimed to save up to 85% of previous assembly times on airframes and airframe parts. Introduced by *Standard Pressed Steel Co.*, Jenkintown, Pa., and *Cooper Precision Products*, Los Angeles, Calif., the new fasteners incorporate the patented Nylok principle (see M&M, July '56, p 146) and are reported to be virtually vibrationproof. The Nylok principle makes use of the elastic properties of nylon to provide self-locking action on threaded fasteners that might otherwise loosen under se-

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vere shaking and jarring.

The plastic memory of the nylon pellet permits repeated use of a given fastener up to 15 times without effectively reducing holding power or the breakaway torque required for removal. Average removal torque encountered after 15 removals on a test of 20 aircraft fasteners containing nylon inserts was just under 15 in.-lb, more than double the allowable minimum of 6.5 in.-lb. Torque required for the first removal did not exceed 52 in.-lb, which is 8 in.-lb under the maximum allowed.

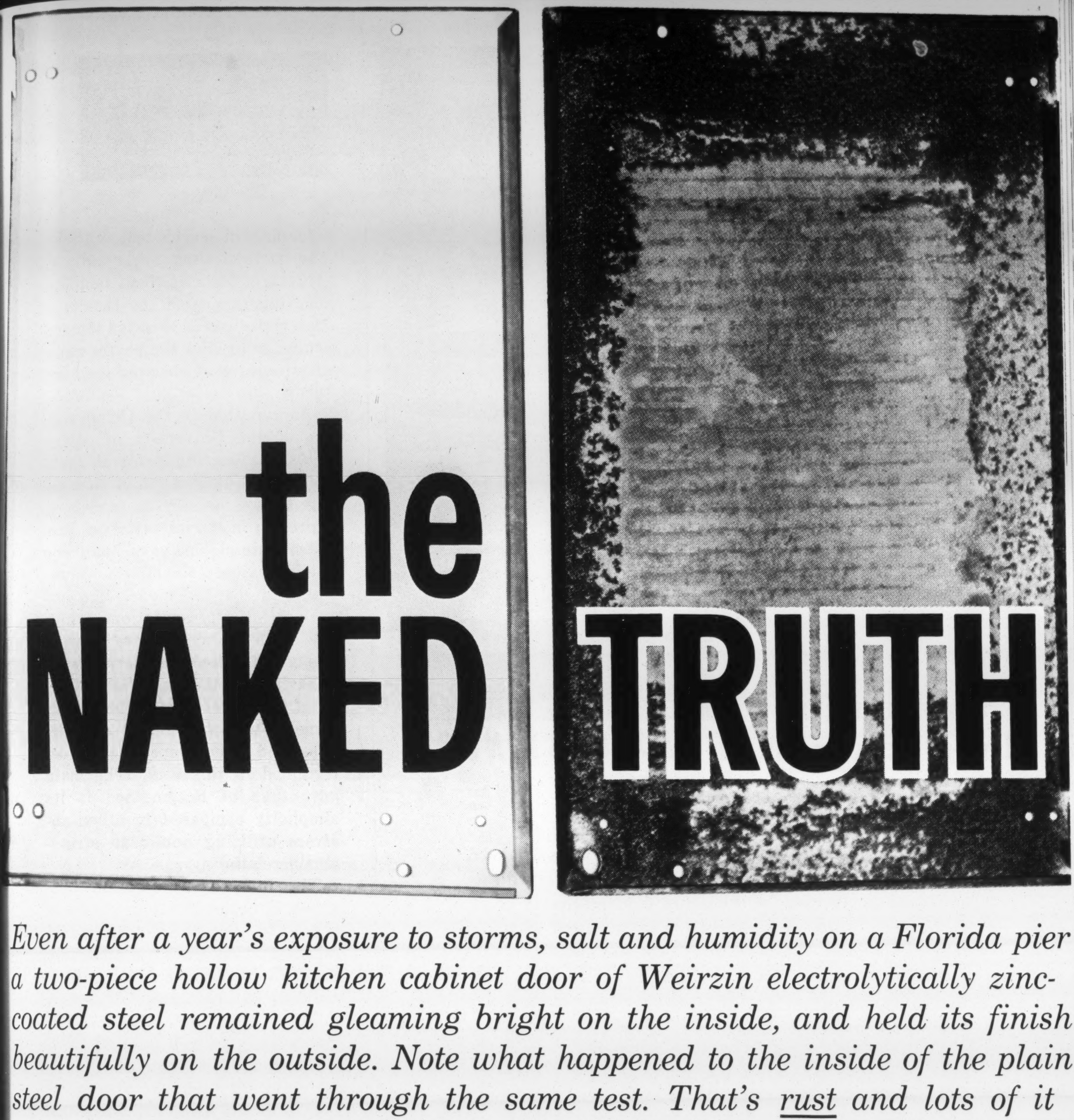
Tensile values of over 29,000 psi, based on random samples from the same lot, show that nylon pellets when inserted in the threads of an aircraft bolt do not alter the bolt's ultimate strength. Bolts with and without nylon inserts from the same lot have an identical response to equal tensile forces when elongated within the elastic range of the material used in the fastener.

In order to preload a Nylok fastener to the same stress level as a standard fastener of the same kind, additional torque is recommended. Failure to apply this additional torque may result in preloads below the desired level.

The nylon inserts are available on a wide variety of fastener types and configurations, including high strength steel aircraft bolts and titanium tension-fatigue bolts. The inserts are approved for use at temperatures up to 250 F and are said to be resistant to water, commercial solvents, alcohol, gasoline and oils.

New Method Eliminates Hot Tests of Structures

A new method of evaluating aircraft structures for high temperature service may greatly speed up the process of designing aircraft by eliminating the necessity for much of the expensive and time-consuming testing of the



Even after a year's exposure to storms, salt and humidity on a Florida pier a two-piece hollow kitchen cabinet door of Weirzin electrolytically zinc-coated steel remained gleaming bright on the inside, and held its finish beautifully on the outside. Note what happened to the inside of the plain steel door that went through the same test. That's rust and lots of it . . . a completely ruined product both inside and out.

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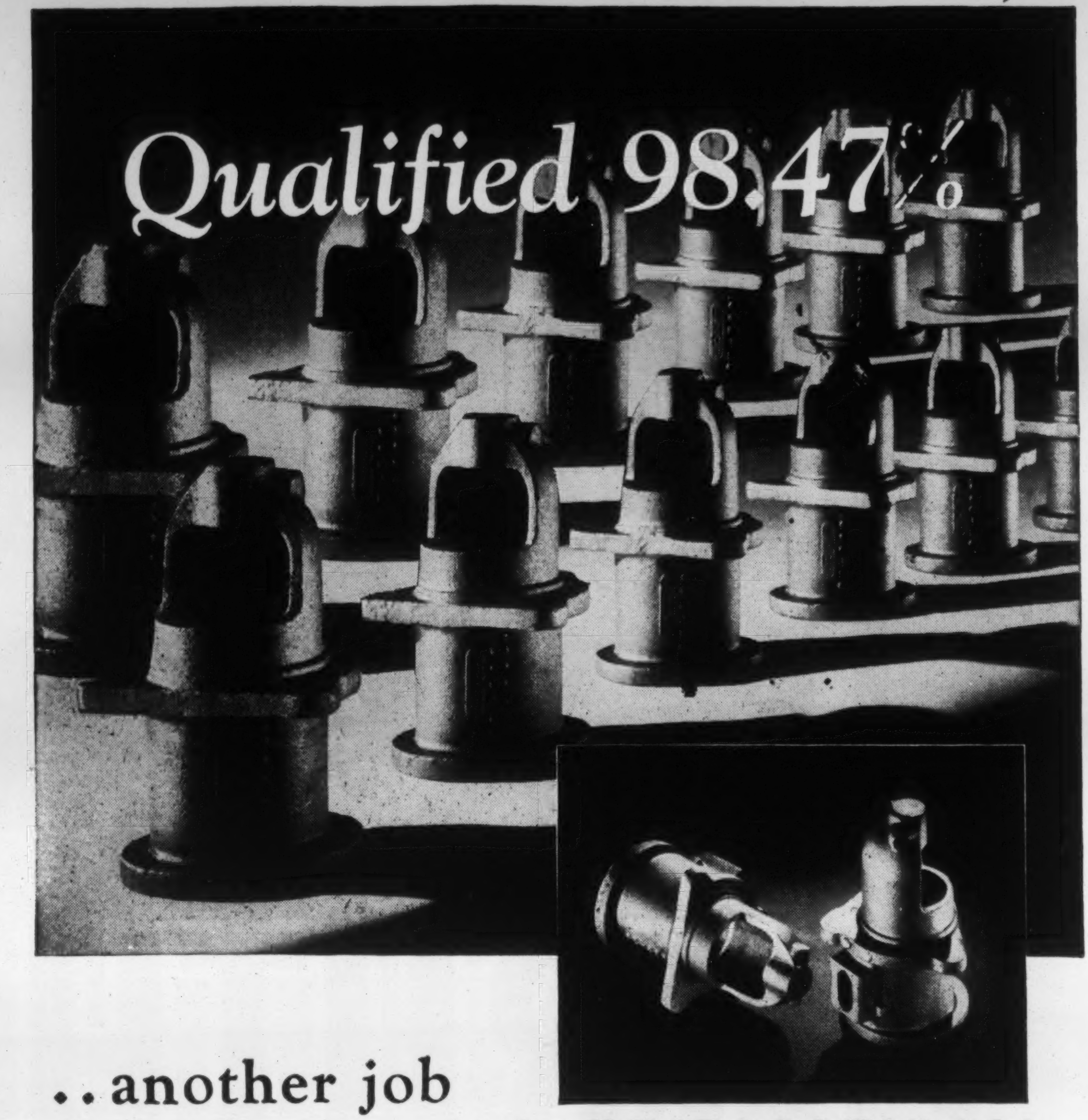

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structures at service temperatures. The method uses the results of structural tests at room temperature together with the results of materials tests at elevated temperatures to predict the performance of structures at elevated temperatures.

As reported in the October issue of the University of Michigan's *Engineering Research Institute News,* it was found that using linear mechanical models to represent material behavior provided a simple means of analyzing fairly complex structures. These linear mechanical models are mathematical representations which use springs and dampers in various combinations to determine the behavior of the material. They react to a given force in much the same way as the actual material does, and creep properties are determined in this way. The main advantage of the method is its simplicity compared to other analyses utilizing nonlinear stress-strain relations.

The inherent assumption that stress is proportional to strain is not valid, but the linear model representation leads to relatively simple methods of analysis which could be of great value in design work if the limitations of the theory are kept well in mind. The ERI group felt that the linear model would probably give good results in any structure when the stress did not vary over a wide range in time or within the structure.

One method by which the stress level effect could be incorporated into the calculations is the determination of the family of memory functions for the material at various stress levels. By means of the memory functions, the stress-strain effect at a given temperature and time is represented. These functions mathematically relate the behavior of the linear model to the structural material. The constants used in this function are determined by the con-

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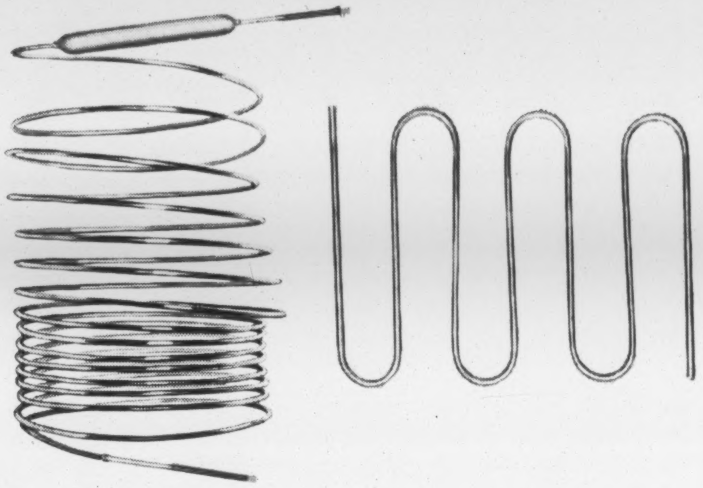
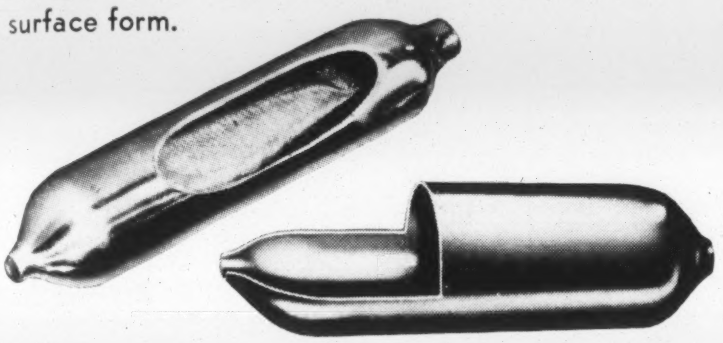


Representative of Wolverine's fabrication techniques are these evaporator sub-assembly, left, and serpentine coil.



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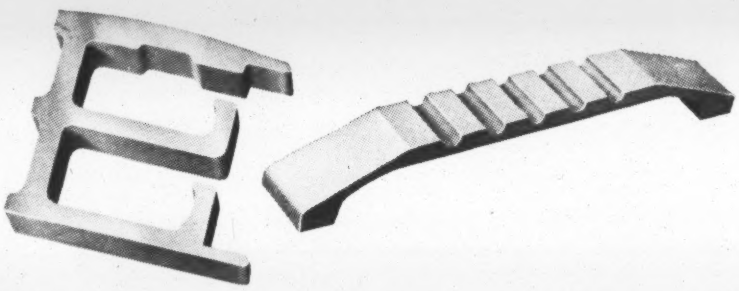

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[†] PROCESS PATENT APPLIED FOR

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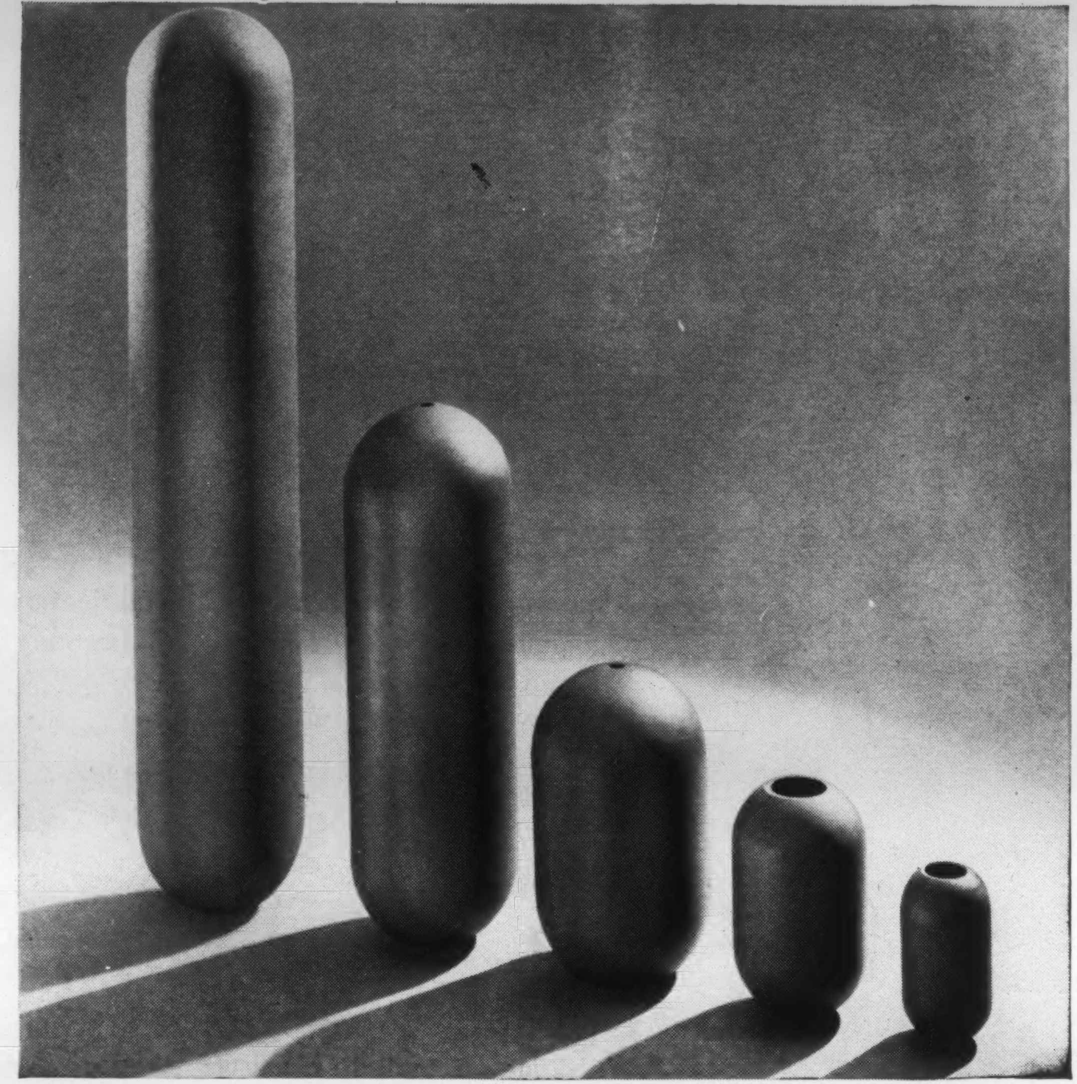

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stants of the material. This procedure would at least give a rough approximation to the true solutions, including the effect of stress level. In particular, if in the calculations based on the linear model representations the memory functions corresponding to the highest stress level to be expected were always used, the theory would give upper bounds on the deformations to be expected.

Test procedure

Since the tests were to be carried out at elevated temperatures, a special oven was designed and built in the Structures Laboratory of the University of Michigan. The tests consisted of the application of distributed lateral loads to six aluminum alloy fins from the AT-6 airplane. The tests were carried out at temperatures ranging from 75 to 7000 F. The fins were mounted on a steel supporting jig and enclosed in the oven. Load was applied by means of a linkage which simulated uniformly distributed loads. The total load comprised rapidly applied destructive loads, as well as smaller loads applied for longer periods of time until the structure failed by creep buckling.

Results of tests

The investigators found that:

1. The maximum load that could be supported decreased as temperature increased, as was expected.

2. It is possible to predict the elevated temperature strength of a structure with reasonable accuracy from the properties of the material at elevated temperature and the results of structural tests carried out at room temperature. The fact that all failures occurred in the same manner and at the same location indicated that, at least for structures which were predominantly of one material, behavior at steady elevated temperatures would not be significantly different from that at room temperature, except for the fact that the ability to carry a load would decrease.

3. It is possible to determine the

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For more information, turn to Reader Service Card, Circle No. 507

critical deformation at which instability of the structure tends to develop.

4. It is possible to estimate the time at which a given high speed aircraft should be regarded as unsafe for further flight.

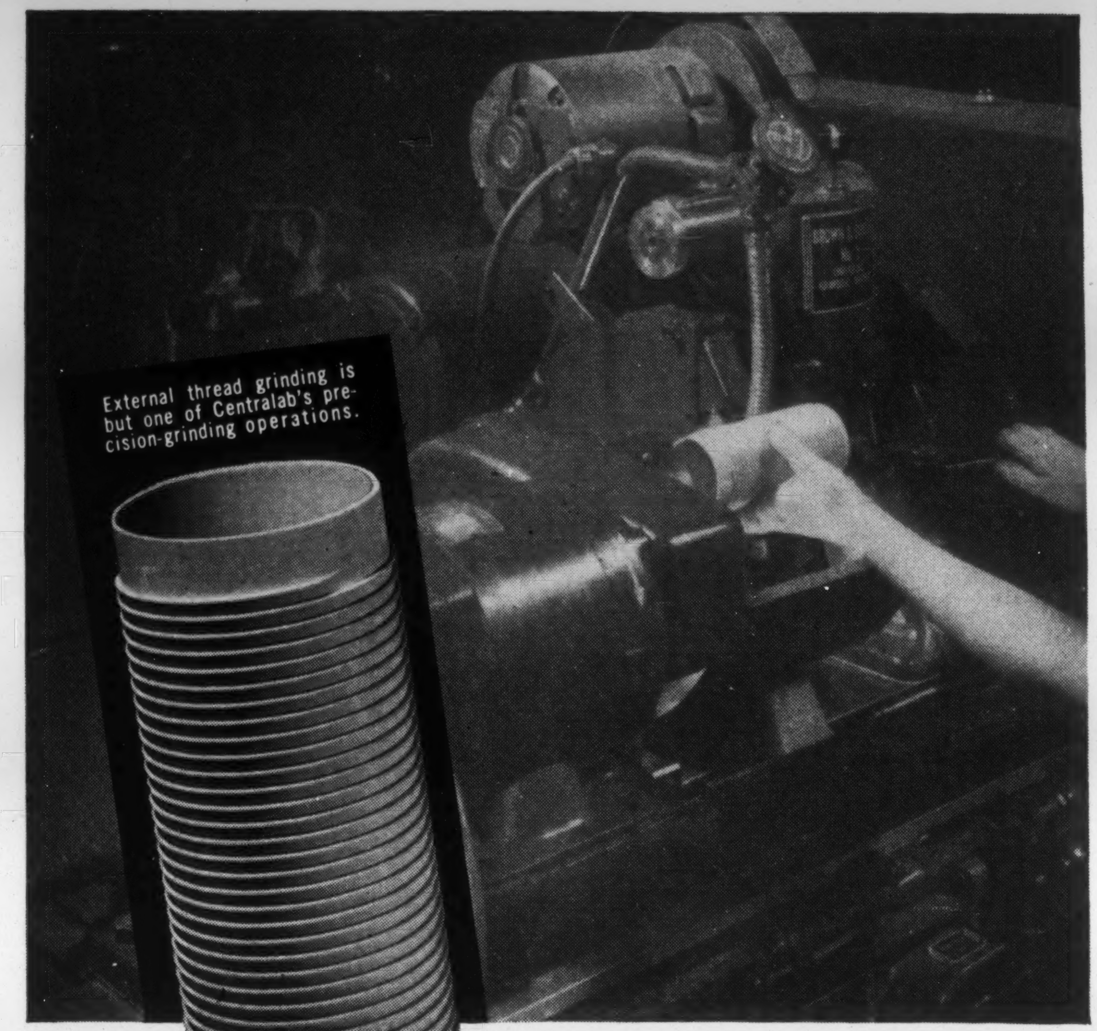
They also concluded that by carrying out additional tests similar to those performed in connection with this project it would be possible to develop empirical methods for estimating 1) ultimate strength of a built-up structure at elevated temperature; 2) the safe life of the structure in terms of flying hours at elevated temperature; and 3) the permissible load factor at any time during the life of the craft—all these if the ultimate strength and maximum deflection of the structure at room temperature and the properties of the material at room and elevated temperatures were known. They stated that conventional aluminum alloys would probably prove to be reasonably satisfactory from the standpoint of strength at temperatures up to 600 F, although the weight of such structures would be considerably greater than that necessary at room temperatures and the life might not be more than a few hundred hours.

Acrylate Coatings for Solvent Resistance

Flexible, acrylate-base surface coatings made of Vyram rubber are currently being evaluated by the *Development Dept., Monsanto Chemical Co.,* Nitro, W. Va. for use in both petroleum and ester-based hydraulic fluids. Vyram acrylate elastomer was originally developed by Monsanto as a solvent resistant rubber (see M&M, June '55, p 148).

The company has successfully worked out methods for putting the polymer into solution. However, use of the material as a coating will require considerable study

For more information, Circle No. 599 ➤



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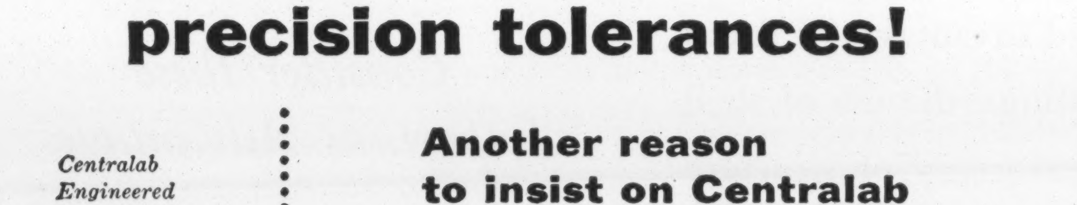


For more information, turn to Reader Service Card, Circle No. 579

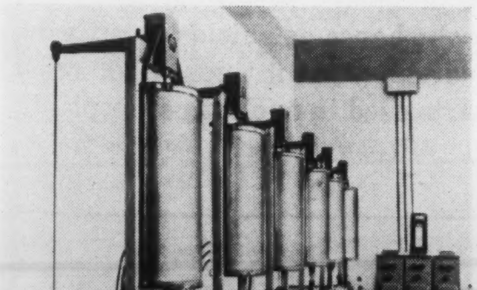
for adaptation and refinement. Only black coatings can be supplied at present.

The acrylate coatings have been found to adhere well to steel, aluminum and rubber. They are expected to be suitable as finishes for metal and as coatings for such conventional rubber items as machine mounts, cushions, liners, wiring and hoses.

The coatings can be sprayed, dipped or brushed. Films dry to the touch in about 4 hr at room temperature, a full cure requiring about 72 hr at 70-90 F. Curing at 212 F gives a full cure in about 30 min. Prolonged curing at temperatures above 300 F results in continued hardening of the film surface with some loss of flexibility. The mixed catalyzed material has a shelf life of approximately 8-12 hr at room temperature.

Creep Strain Tester Developed in Germany

A low cost creep strain tester for testing metals at high temperatures has recently been introduced by the West German firm of *Mohr & Federhaff*, Mannheim, Germany. The tester, said to occupy about as much floor space as a typewriter, is available in two basic models. One model contains units in multiples of five furnaces



Battery *of twelve creep strain testers developed and manufactured in Western Germany.*

For more information, Circle No. 419 ➤

This is an actual photo of a surface prepared by polishing and etching a cross-section of a forging, to reveal the "grain flow." (x2)

A PICTURE OF ADVANTAGES YOU CAN GET ONLY FROM FORGINGS

In the picture above you see the grain flow in a forging.

This picture demonstrates two things. First, the metal is dense and free from porosity. The impact or pressure of forging helps make it so. Such density is important when parts must have machined surfaces, when they must provide reliable strength and safety, and when they must be tight against leakage of liquids or gases. This quality reduces rejects and saves money. It contributes to safety and saves lives.

Second, notice how grain flow lines follow the shape of the part. This improves impact resistance and fatigue strength of the part. In closed-die forging, these flow lines can be positioned, to give maximum properties where they are needed. As a result, forged parts can be lighter, safer, stronger, and frequently less costly.

Thus this picture shows you why forged metal is *metal you can trust.* You can trust forgings for performance, and to save money. Find out how forgings can improve your products, your costs. Consult a *Forging Engineer*, and send for the booklets offered below.

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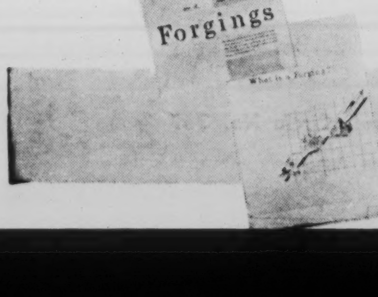
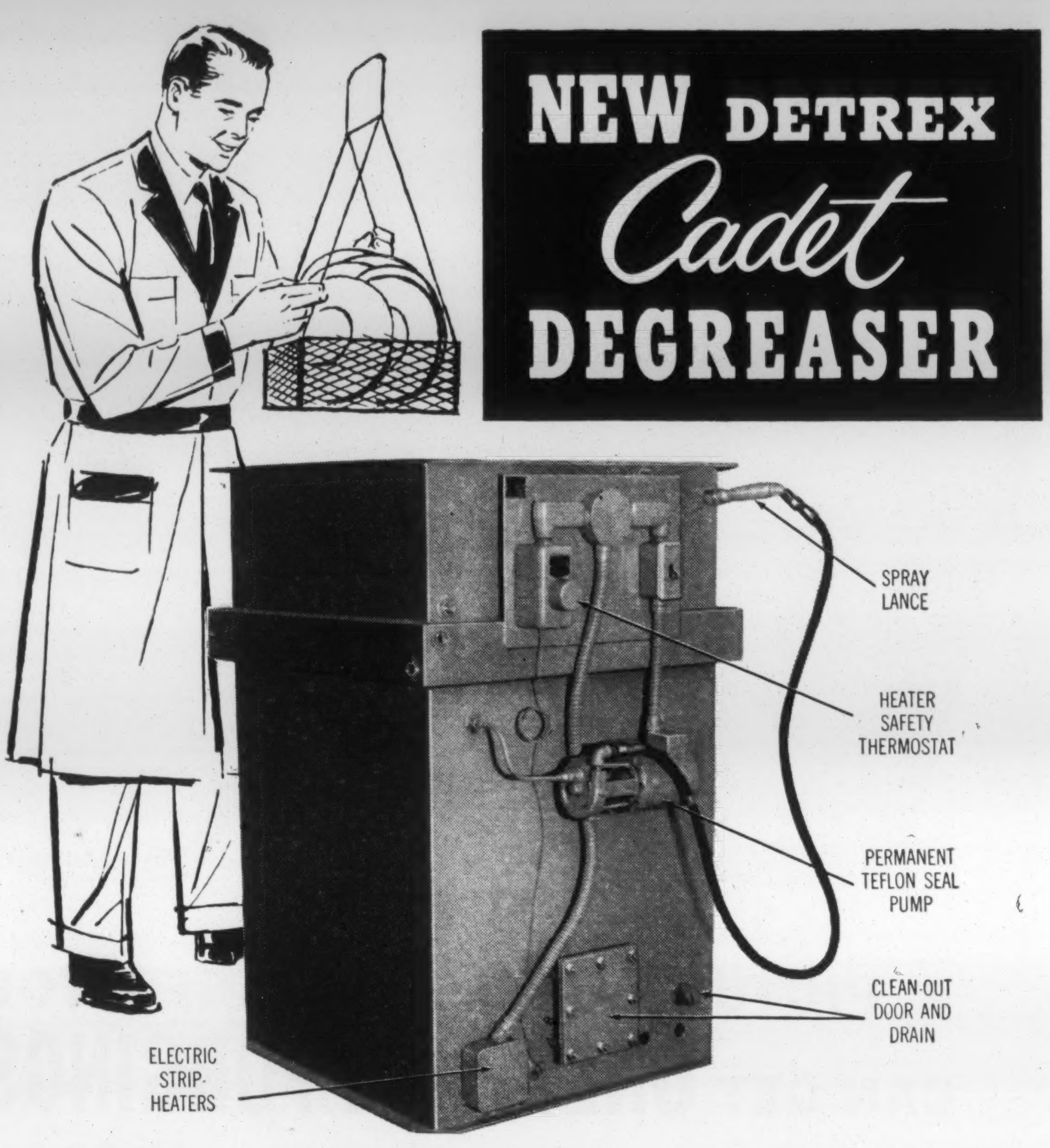


NEW DETREX *Cadet* DEGREASER



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with each furnace designed to hold a single sample. Each individual furnace of the unit can be run at different temperatures and stresses if so desired. The other model is a single furnace unit designed to test up to 10 samples simultaneously.

Testing temperatures for both models range from 0 to 1832 F, and temperature readings, accurate to within ±41 F, can be instantly read and recorded. According to company officials, the construction of the individual units allows for one set of electrical controls to serve a battery of as many as 50 furnaces at once.

Further information on the testers may be obtained from R. L. Simons, 50 Broad St., New York 4, N.Y.

Filled Epoxy Resin for Radiation Shields

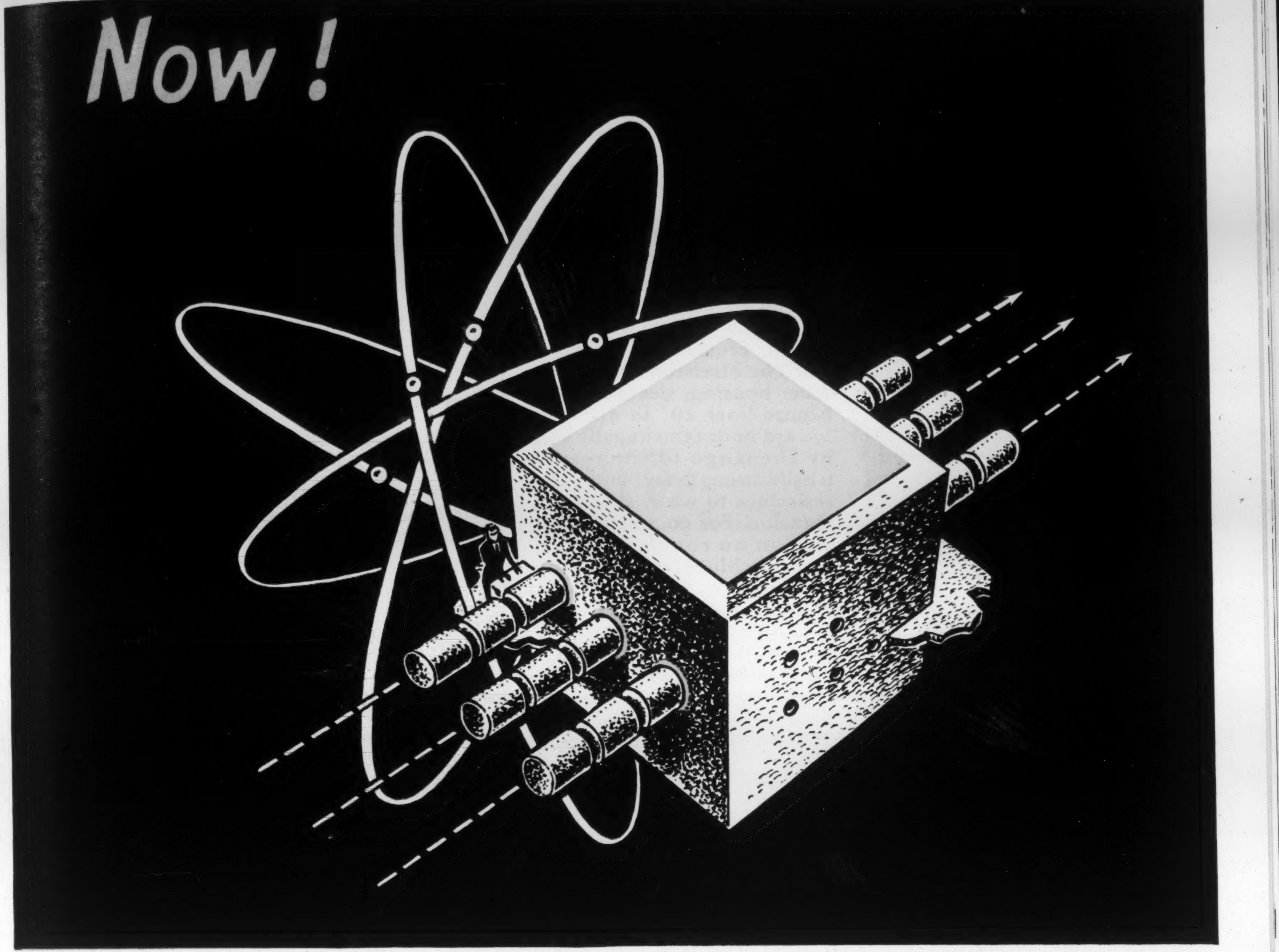
A high density, filled epoxy casting resin has been developed by *Furane Plastics, Inc.,* 4516 Brazil St., Los Angeles 39, Calif., to act as a shield against harmful radiation from nuclear reactors. Called Epocast 11-C, the casting resin is said to arrest alpha and beta radiation and to offer substantial resistance to gamma radiation.

The resin sets rapidly at room temperatures. It can be cast into rectangular shielding and into such shapes as shields about valve bodies, pipe fittings and other parts used in nuclear power plants.

(more What's New on p 194)

Correction

In the Jan '57 article, "Nickel-Free Stainless Steel," the expression "chromium-manganese-nickel," which appears on page 104, column 3, line 7, and page 105, column 1, line 13, should read "chromium-manganese-nitrogen."



Norton ceramic fuel elements

Separate facility now producing ceramic fuel elements and various reactor components

To meet the demand for more-economical, more-efficient reactor fuels, the trend is towards ceramic types — because of their greater resistance to corrosion and radiation, the ease with which they can be reprocessed, and their ability to operate at higher temperatures. Norton Company's long experience in the development of high-purity ceramics has now led to the commercial production of ceramic fuel elements.

Take Advantage of Norton Assistance in bringing special nuclear materials into successful use in the development of nuclear power plants. In addition to the development and production of ceramic reactor components, Norton experience includes highly specialized refractories for missile, metallurgy, chemical, and furnace applications. These top-performing Norton refractory ℞'s — *engineered and prescribed* for the widest range of uses — are of increasing interest to nuclear engineers. They include alumina, silicon carbide, thoria, urania, zirconia, magnesia, dolomite, and numerous borides, carbides and nitrides — that have benefited nuclear as well as general industrial developments.

A special Norton Research and Development section, devoted to the development of precision ceramics and familiar with both nuclear and refractories development, co-operates whenever possible with industrial, government and academic research activities. Your progress may be speeded up by utilizing Norton co-operation and products. For further information write to NORTON COMPANY, Refractories Division, 342 New Bond Street, Worcester 6, Massachusetts.

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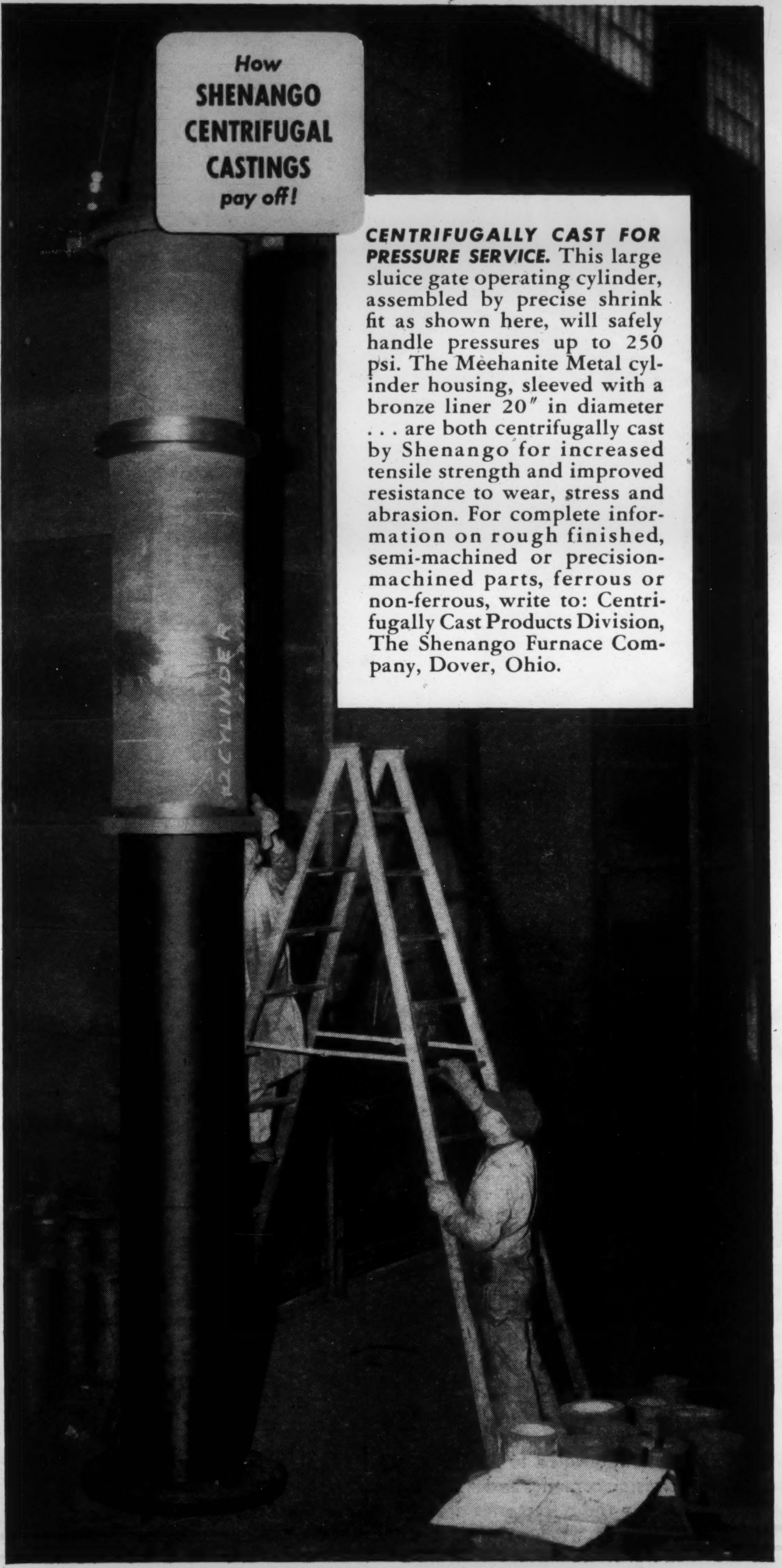

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CENTRIFUGALLY CAST FOR PRESSURE SERVICE. This large sluice gate operating cylinder, assembled by precise shrink fit as shown here, will safely handle pressures up to 250 psi. The Meehanite Metal cylinder housing, sleeved with a bronze liner 20″ in diameter . . . are both centrifugally cast by Shenango for increased tensile strength and improved resistance to wear, stress and abrasion. For complete information on rough finished, semi-machined or precision-machined parts, ferrous or non-ferrous, write to: Centrifugally Cast Products Division, The Shenango Furnace Company, Dover, Ohio.

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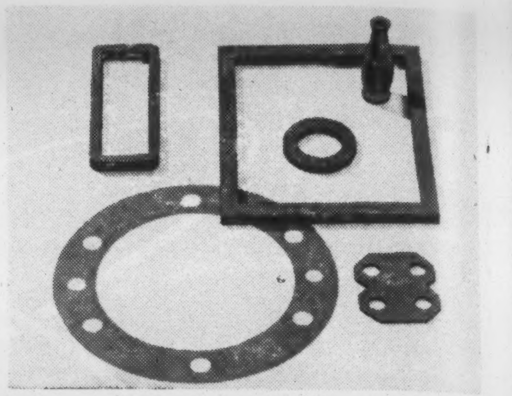

***Some typical parts** made from soft silicone rubber.*

Two Silicone Rubbers

Two new silicone rubber compounds have recently been introduced. One is a very soft silicone rubber available in sheets, moldings and extrusions. The other is a low compression set material.

1. Soft rubber

A soft (27 durometer) silicone rubber stock that is said to have compressibility properties in the range of silicone sponge rubber has been developed by *Connecticut Hard Rubber Co.*, 407 East St., New Haven 9, Conn. Silicone sponge rubber is slightly softer than this new material, but not as readily moldable, the company says.

Called Cohrlastic R-11568, the soft silicone rubber will be available initially in sheets, moldings and extrusions. Sheets are available in thicknesses from 1/16 to ½ in., moldings in 1/16 to 1-in. sections, and extrusions in 10-ft lengths.

The soft sealing material, which is adaptable to complicated shapes,

TYPICAL PROPERTIES OF COHRLASTIC R011568

Tensile Strength, psi	718
Elongation, %	450
Hardness, Durometer A	27
Tear Strength, lb/in.	31.5
Dry Heat Resistance (24 hr at 450 F), durometer A hardness change	+2
Compression Set (22 hr at 350 F, 60% comp), %	29

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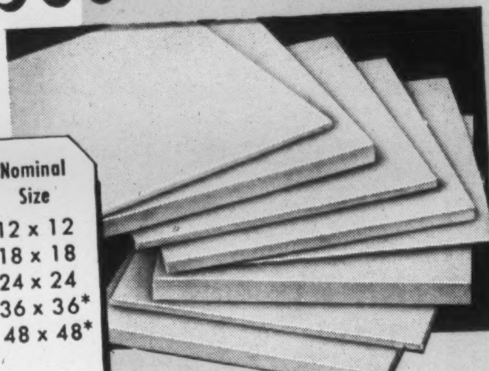
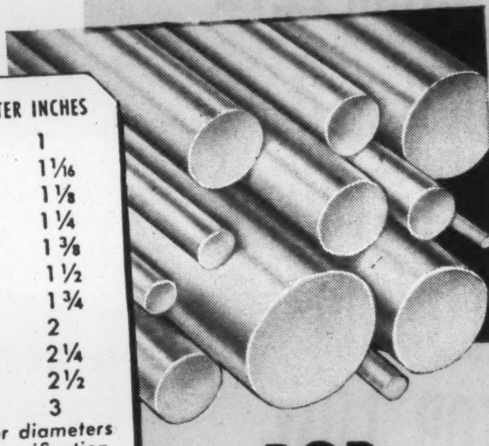


Thickness Inches	Nominal Size
1/16	12 x 12
3/32	18 x 18
1/8	24 x 24
3/16	36 x 36*
1/4	48 x 48*
3/8	
1/2 & Up	

* Can be furnished in 1/2 sheets

SHEET



DIAMETER INCHES

1/4	1
5/16	1 1/16
3/8	1 1/8
7/16	1 1/4
1/2	1 3/8
9/16	1 1/2
5/8	1 3/4
3/4	2
7/8	2 1/4
	2 1/2
	3

Other diameters on specification

ROD

TYPICAL SIZES INCHES

O. D.	I. D.
3/8	1/4
1/2	3/8
3/4	1/2
1	3/4
1 1/2	1
2 1/2	1 1/2
3	1 3/4

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has a temperature range of −100 to 500 F. It is odorless, tasteless, noncorrosive and noncontaminating, and it is resistant to ozone and weathering.

2. Low set rubber

Designated SE-751, a low compression set silicone rubber that is said to withstand intermittent temperatures as high as 600 F has been introduced by *Silicone Products Dept., General Electric Co.*, Waterford, N.Y. A 50 durometer compound in GE's Class 700 silicone rubber series, SE-751, can be made harder by adding certain diatomaceous fillers.

The material can be extruded and calendered easily, and has low shrinkage and low water absorption. The improved silicone rubber is particularly recommended for door seals in domestic and industrial ovens.

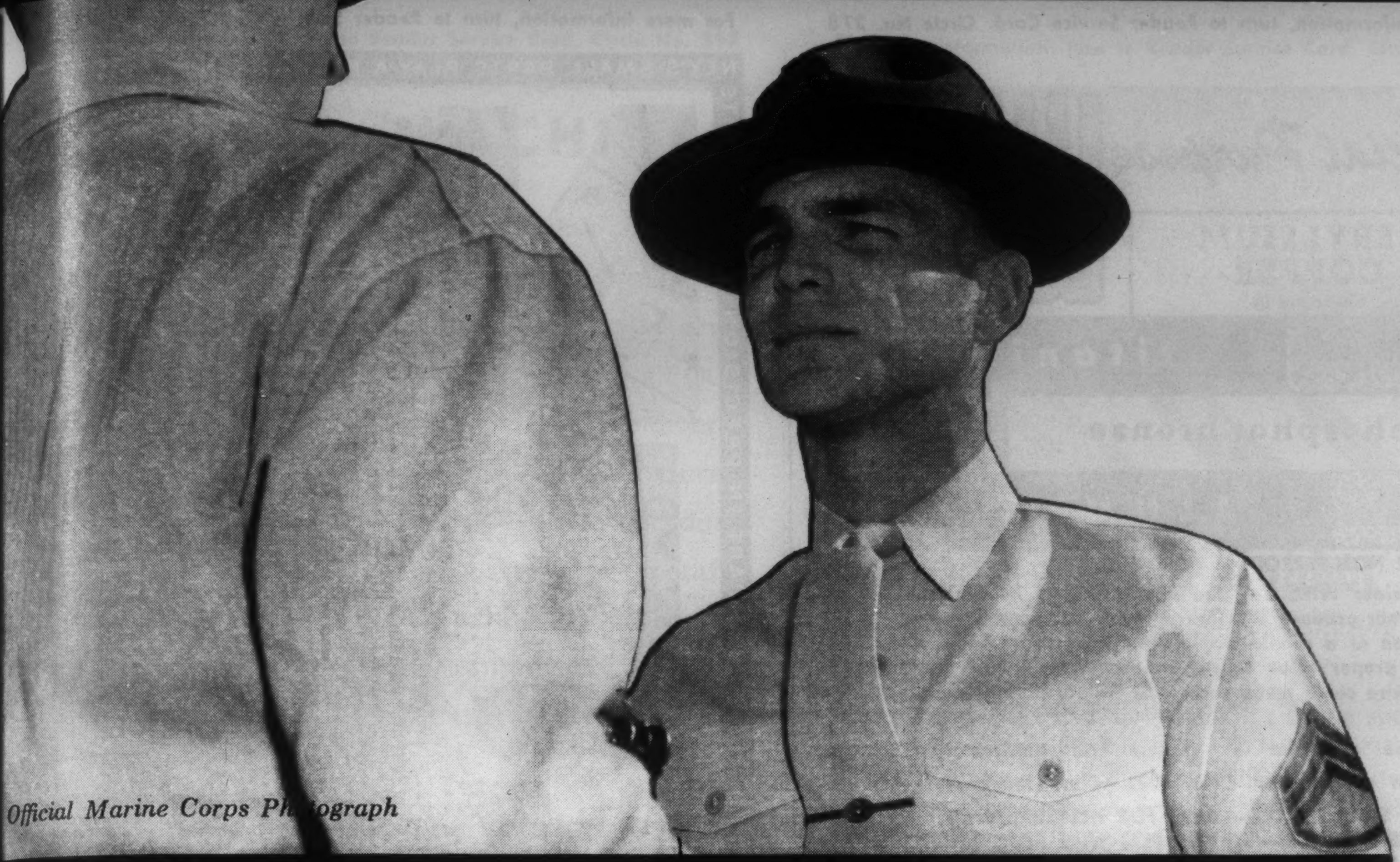
Properties of Metals at Low Temperatures

Low temperature research is providing much valuable information regarding flow and fracture properties of metals. For example, it has been found that at extremely low temperatures only metals with a body centered cubic structure show a strong dependence of yield strength upon temperature. However, the yield strength of these metals does not increase as rapidly at the lower temperatures as predicted by current theories of the temperature dependence of yield strength. Quenched and tempered steels and beta-brass exhibit considerable plastic deformation at −450 F.

E. T. Wessel, in a paper delivered at the 38th annual convention of the American Society for Metals, further points out that the face centered cubic metal, nickel, and the close packed hexagonal metal, zirconium, show only slight dependence of yield strength upon

(continued on p 200)

For more information, Circle No. 394 ➤



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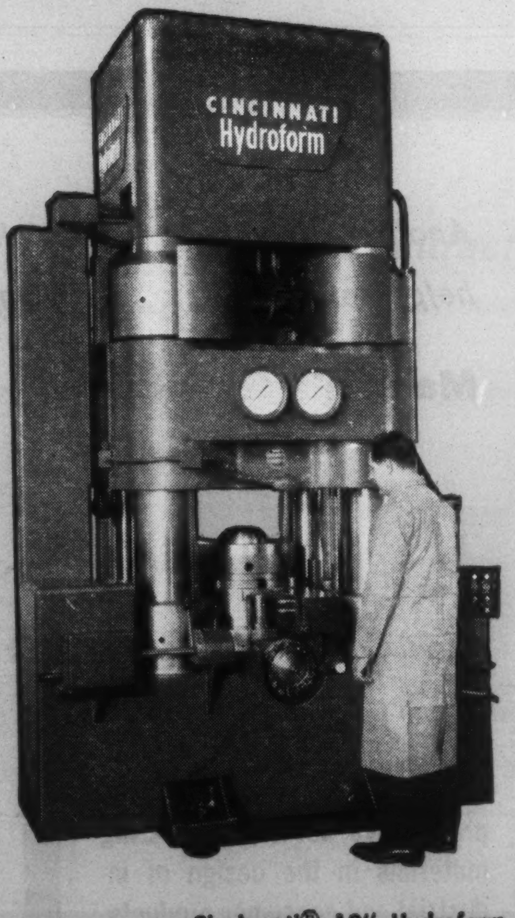

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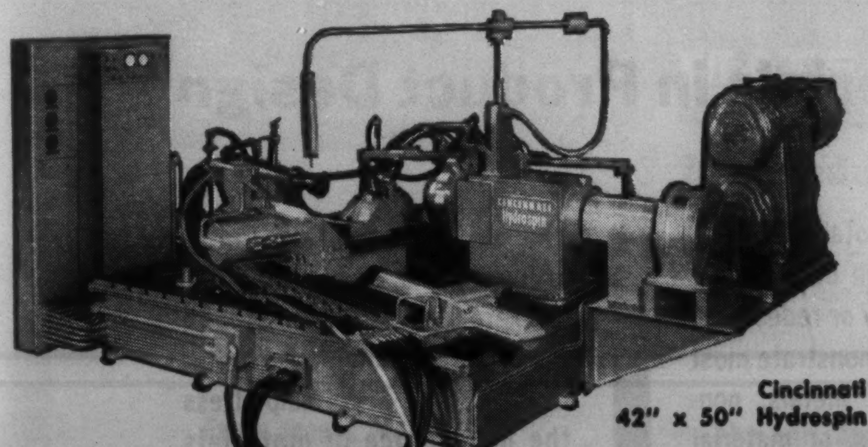

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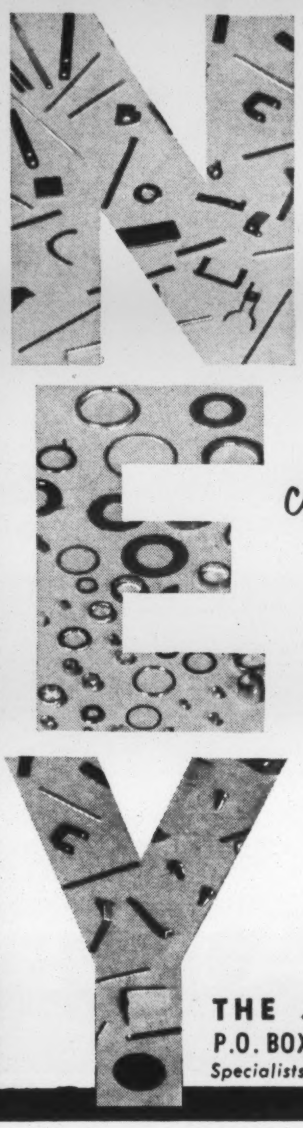

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Sixteen awards totalling $2,000 in cash prizes will be made for the products—new or redesigned in 1956—that demonstrate most effective use of metals, nonmetallics, finishes, or material forms (i.e., castings, forgings, moldings, extrusions, etc.).

The M&M Awards Competition is certain to help widen the markets for materials by focusing attention on new and better uses. Further, it will help stress the importance of materials selection in the engineering and design of better products.

Judges: *Joseph L.* ***Bonanno,*** *Chief Engineer, Lionel Corp.; John P.* ***Nielsen,*** *Chairman, Department of Metallurgical Engineering, New York University; John B.* ***Seastone,*** *Director, Technical Division, Olin Mathieson Chemical Corp.; Walter Dorwin* ***Teague,*** *Industrial Designer, Walter Dorwin Teague Associates.*

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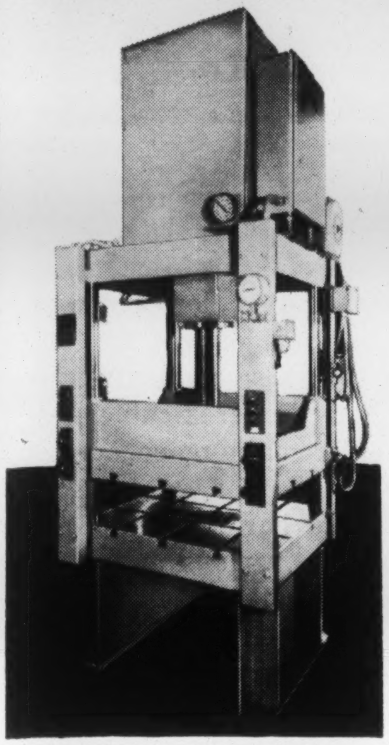
SPECIAL MACHINES



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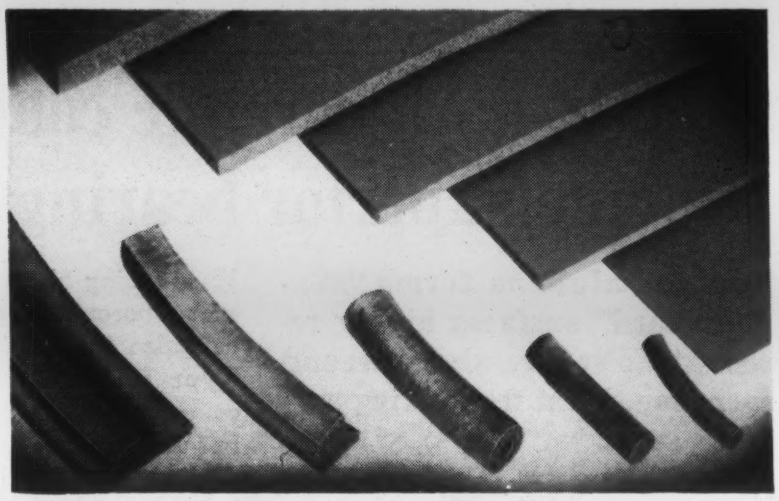

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Low density COHRlastic R-10470 silicone sponge rubber is completely flexible after 72 hrs. at 480°F, shows no brittleness after 5 hrs. at −100°F. High tensile and tear strengths provide unusual elongation, closed cell construction is non-absorbing. R-10470 is called out on many aircraft and electronic prints . . . meets specs: MCI 4546; BMS 1-23; Scintilla 0-3143; Sperry P.691,764 (type HTM). Available from stock in sheets 1/16″ thru 1/2″, in rod .180″ thru .585″. Special extruded shapes made to order.

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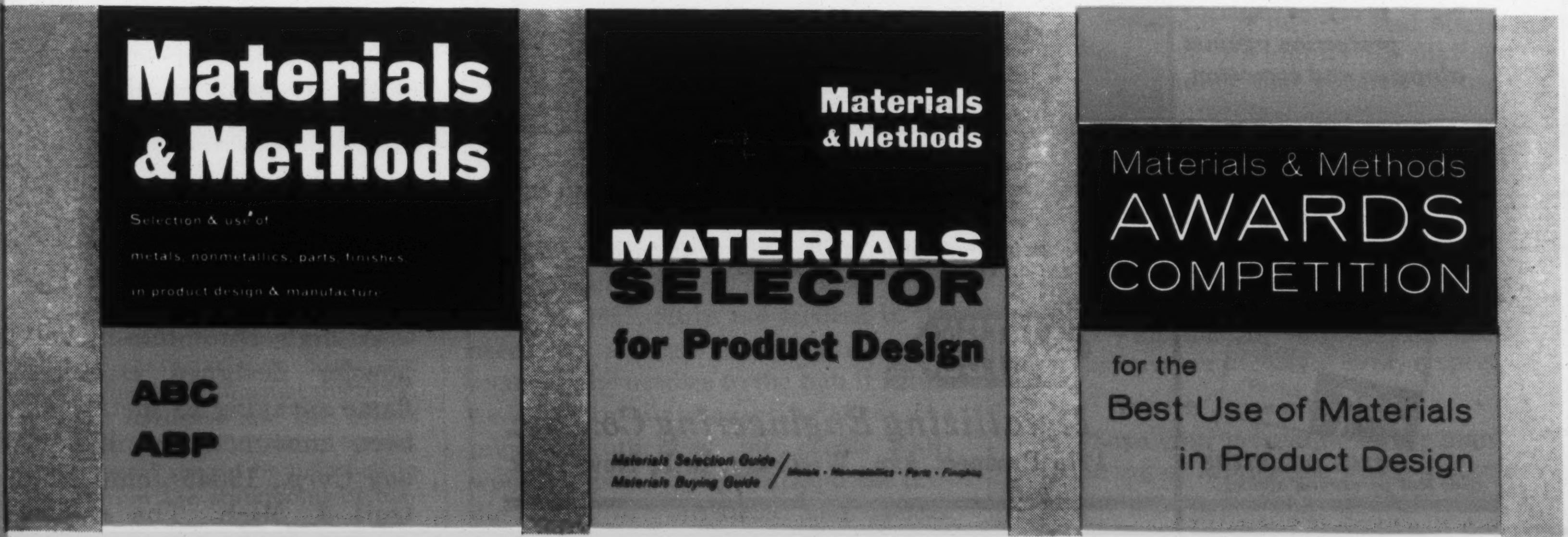
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1 **Every month M&M** publishes more editorial and advertising pages on how and where to use engineering materials than any other magazine.

2 The only **annual reference issue** devoted exclusively to materials selection. Entirely in data sheet form, it is the most complete annual engineering materials reference published.

3 The only publication-sponsored **awards competition** for the best use of materials, parts and finishes in the design of industrial and consumer products.

Materials & Methods / *A Reinhold Publication* / *430 Park Avenue, New York 22, New York*

NEW IMPROVED HARD FACING

Tough, hard ceramic coatings provide superior bearing surfaces

Sprayed alumina forms "sapphire-hard" surfaces highly resistant to wear, abrasion and corrosion. Ideal for bearing surfaces, seals.

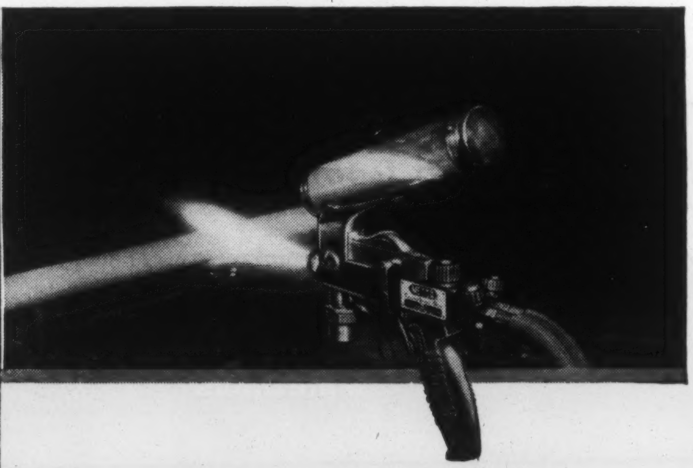
Development of the new METCO THERMOSPRAY GUN for spraying high-melting-point ceramic materials at low cost opens up a variety of new practical applications. One that has produced a great deal of interest is the use of sprayed alumina coatings for bearing surfaces and mechanical seals. This THERMOSPRAY 101 Ceramic Powder produces surfaces with a hardness of 9.0 on the Moh scale, (only the diamond rates 10.0) with excellent resistance to wear, abrasion and corrosion. When used in combination with special phenolic or furane plastic sealers it provides superior protection against many acids.

Another THERMOSPRAY Powder – 201 – is zirconia which is somewhat softer than No. 101 but provides superior heat-insulating properties. Melting point of this material is 4600° F. and particle hardness 8.0 on the Moh scale.

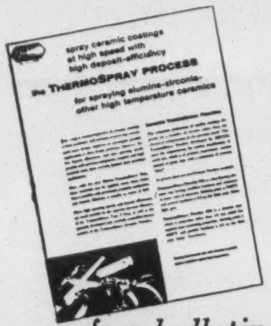
Hard-facing alloys of the self-fluxing, nickel-boron-silicon type in powder form can also be applied with the METCO Type P THERMOSPRAY GUN. These coatings may be fused, semi-fused, or left unfused depending on the hardness desired, from RC 30 to RC 65, depending on the alloy and the process used.

The new THERMOSPRAY GUN operates without compressed air, only oxygen and acetylene being required. The free-flowing THERMOSPRAY powders are fed to the flame nozzle from a hopper atop the gun, melted and propelied to the surface to be coated. These materials are sprayed many times faster (up to 15 sq. ft. per hour–.010" thick) than has been possible with equipment previously available. Deposit efficiencies are in excess of 95%. These factors result in extremely low coating costs.

Preliminary engineering data contained in Bulletin 127 covers ceramic coatings while Bulletin 126 covers the hard-facing alloys. Either or both may be obtained by filling out the coupon below or writing on your company's letterhead. No obligation, of course.



Pump rod sprayed with alumina provides superior protection against abrasion and corrosion.



free bulletins
(See last paragraph above)

The following trade names are the property of Metallizing Engineering Co., Inc. METCO, THERMOSPRAY. *Reg. U.S. Pat. Off.*

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1175 Prospect Ave., Westbury, L. I., New York

Please send me ☐ free Bulletin 127 (ceramic coatings)
☐ free Bulletin 126 (hard-facing).

Name

Title Company

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For more information, turn to Reader Service Card, Circle No. 519

What's new IN MATERIALS

temperature. The lack of any temperature dependence of yield strength at the lower temperatures is considerably more pronounced in these metals than it is in the body centered cubic metals, the yield remaining constant below —240 F.

The work hardening characteristics of the various materials as related to test temperature may be divided into two categories: the face centered cubic and close packed hexagonal metals show a decided increase in capacity for work hardening at low temperatures, whereas the body centered cubic metals show a decided decrease in ability to work harden.

During the investigation, the author observed that quenched and tempered alloy steels do not show the usual large percentage increase of yield strength with decreased test temperature that is characteristic of the body centered cubic metals. The author feels that this behavior is due to an initial high room temperature yield strength resulting from carbide particle size, shape and distribution. He proposes a relationship which provides a simple method of approximating the temperature dependence of the yield strength of alloy steels.

New Metal Powder for Flame Spraying

A high chromium-nickel metal powder designed especially for flame spraying of metal parts has been announced by *Wall Colmonoy Corp.*, 19345 John R St., Detroit 3, Mich. The as-deposited metal features a low coefficient of friction, controlled surface porosity and good oil retention properties.

Designated Colmonoy C-250 powder, the hard facing material contains chromium borides. It is recommended for reclaiming worn or scored crankshafts, for salvage

BRIDGEPORT BRASS
COPPER ALLOY BULLETIN

Reporting New Developments in Copper-Brass Alloys and Metalworking Methods

Two Easily Machined Bridgeport Alloys That Offer Outstanding Advantages

by M. A. BUELL
Chief Staff Metallurgist

When everyday requirements call for dependable, fast-cutting rod, consideration should be given to two outstanding free-cutting alloys:

Bridgeport Alloy No. 6, the standard free-cutting brass rod, has exceptionally free-machining qualities. Containing 61% copper, 3.4% lead and 35.6% zinc, it has a uniform composition and can be finished to extremely close tolerances.

Bridgeport Tellurium Copper Alloy No. 112 offers unusually good machinability—90 as compared to 100 for free-cutting brass Alloy No. 6—but it also has extremely high electrical and thermal conductivity ratings as well as unusually high resistance to corrosion.

Tellurium Copper No. 112 is ideal for all types of electrical parts, welding torch and soldering iron tips, as well as any other heat- and electrical-conducting parts requiring considerable machining.

Comparative ratings of each alloy are given below.

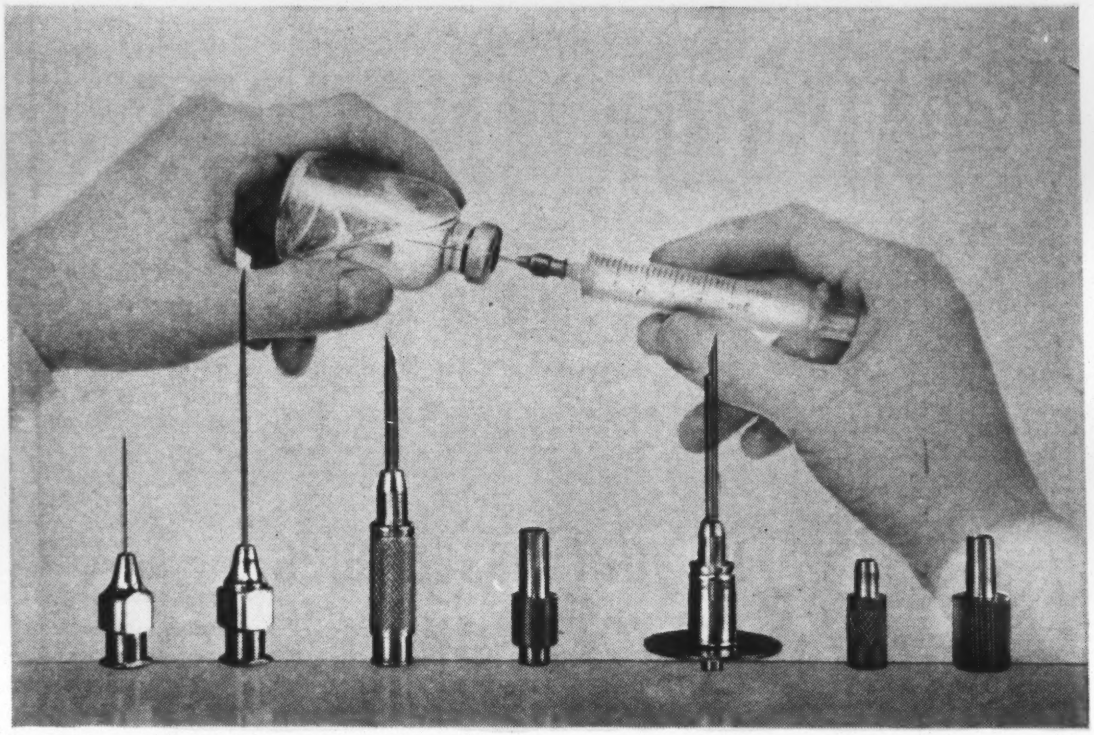
	Free-Machining Brass No. 6	Tellurium Copper No. 112
Thermal Conductivity*	67	204
Electrical Conductivity**	26	90
Machinability Rating	100	90
Cold-Working	Poor	Good
Hot-Working	Fair	Good
Hot-Working Range °F	1300-1450	1400-1600

*Btu/sq ft/ft/hr/°F @ 68° F
**% IACS @ 68° F Soft

Quick Way To Solve Your Metals Problems

Brass, copper and bronze alloys are all available in a widely varying range and combination of characteristics. Some are free-cutting, some have unusual ductility, others intrinsic hardness and still others high tensile strength. For best results, however, the metal should be matched to the job, both from the standpoint of machining as well as eventual product use. An easy way to get the answer to these questions is to talk over your metals selection problems with your Bridgeport salesman. Backed by Bridgeport's Technical Service, he can give you the finest possible help in solving your metals problem.

Free-Cutting Bridgeport Brass Plays Vital Role In Manufacture Of High-Precision Hypodermic Needles



Roehr Products Company, Inc., Waterbury, Connecticut, and Deland, Florida, manufactures over 1000 different types of hypodermic needles for every kind of medical and veterinary use. Each needle is designed and manufactured to high precision standards and to meet exacting tolerances on inside and outside diameters, finish and concentricity.

Hub Requirements

The hubs—an extremely important part of the needle from the point of view of exact fit—are made of Bridgeport Free-Machining Brass Rod, Alloy No. 6. Hub needle holes range from .018" to .085". Hubs are secured to the needles in a single press operation. In securing the needles to the hub it is imperative to avoid exerting excessive pressure—otherwise the needle walls would be pressed together and the needle would be constricted and useless. At the same time, the closure of the hub around the needle must be perfectly air- and liquid-tight. Each finished needle is tested under 45 pounds of pressure between the needle and the syringe.

Free-Machining Brass Is Versatile

The adaptability of Alloy No. 6 to the precise requirements of hypodermic needle manufacture is but another of the increasing number of jobs that this all-around alloy does so well. Its outstanding corrosion resistance is especially important in medical and pharmaceutical use. Its affinity for plating is another quality that governs its use in these instruments.

Wide Number of Uses

Many millions of needles are manufactured annually by Roehr—each must be flawless. Vaccine programs, blood banks, hospitals, doctors, veterinarians, research organizations, pharmaceutical houses—all must be sure that the needles they use are perfect in every respect.

Worth Investigating

Perhaps your present or future manufacturing or fabricating needs are not so exacting as Roehr's—perhaps they are more so. In either case, it will pay you to look into the impressive possibilities of Bridgeport Free-Machining Brass. Your Bridgeport salesman, with Bridgeport Technical Service behind him, will be glad to help. Call him.

BRIDGEPORT BRASS
Bridgeport Brass Company, Bridgeport 2, Connecticut, Offices in Principal Cities
In Canada: Noranda Copper and Brass Limited, Montreal

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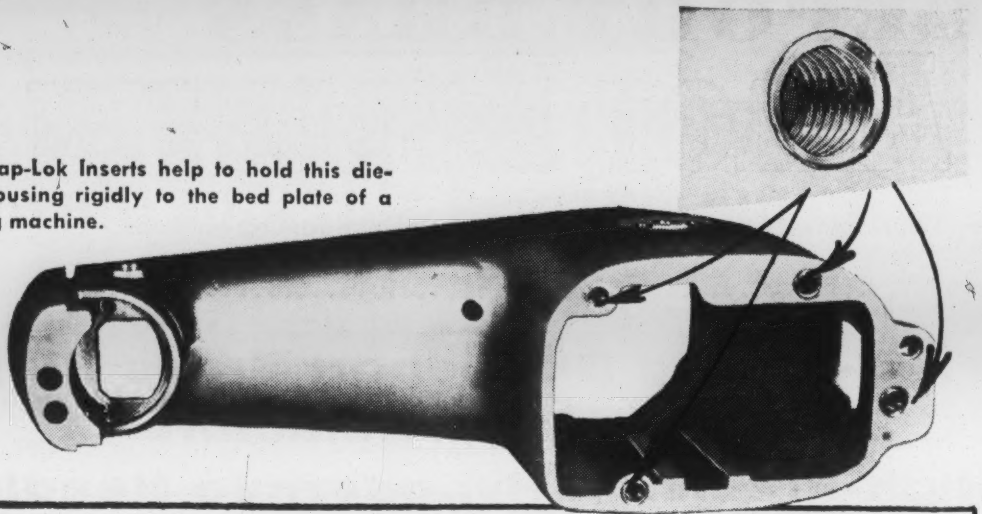


Four Tap-Lok Inserts help to hold this die-cast housing rigidly to the bed plate of a sewing machine.

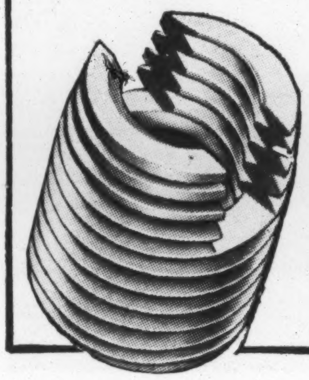
TAP-LOK* INSERTS

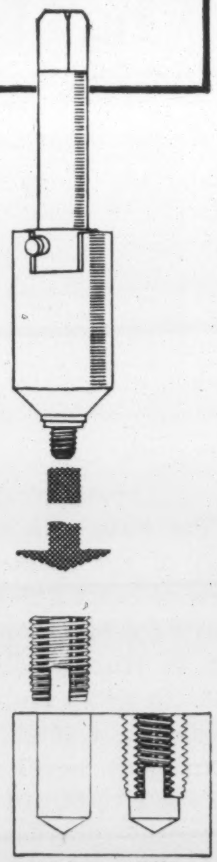
make strong points of the weak spots in your assemblies

Tapped threads in non-ferrous materials are often trouble spots unless protected by some sort of hard bushing. Among the latter the TAP-LOK INSERT has all the good points of other bushings, plus the additional feature of being self-tapping. This, of course eliminates a separate tapping operation and reduces installation costs substantially.

Installation is fast and simple, no fussy hole preparation is necessary, thread crossing is impossible, no secondary operations are required, and installation for production or for maintenance can easily be handled by unskilled operators.

TAP-LOK INSERTS withstand vibration without loosening and have maximum torque-and-pull resistance. One simple driving tool, operated through a standard tapping attachment in a drill press or by hand, is all that is required.





U. S. Patent 2,455,885

*Reg. U. S. Pat. Off.

Send for descriptive folder.

Also manufacturers of Groov-Pins for positive locking press fit.

GROOV-PIN CORPORATION

1123 Hendricks Causeway Ridgefield, New Jersey

For more information, turn to Reader Service Card, Circle No. 373

of crankshafts used in high performance marine engines, and for compressor crankshafts of all kinds. The quality of the mechanical bond that can be obtained, according to the company, depends largely on the cleanliness of the metal surface and on whether proper grit blasting has been used.

Ceramic Coated Steel for Electroluminescence

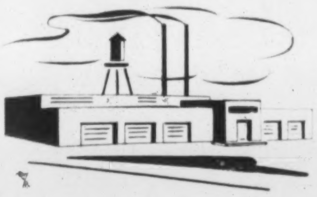
A modified Panelescent lamp produced by Sylvania Electric Co. uses a piece of steel 0.0025 in. thick coated with phosphor and ceramic frit as its base. The material formerly used was an expensive glass which did not lend itself to some of the odd shapes and conditions required of the lamp. (See M&M, Aug '51, p 72).

The phosphor and ceramic frit is fired to the steel and a tin salt is sprayed on the metal to give a sheet of porcelain enamel with a

Darkroom light *is one of the many applications for low intensity Panelescent lamp.*

SAVE with BOSSERT METAL STAMPINGS

SAVE ON CAPITAL INVESTMENT



Considering a plant expansion program to produce stamped metal parts or assemblies for your product? Before you invest . . . investigate Bossert as a dependable source for all your stamping requirements. Our facilities and experience can offer you many production economies.

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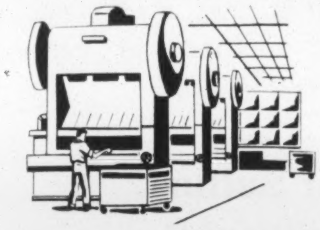


At Bossert, we have the modern, highly-mechanized equipment for economical production line operations. Your job can be carried to any stage of completion with our facilities for machining, welding, grinding, plating, annealing and painting.

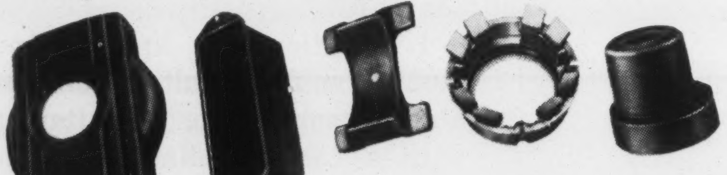
SAVE ON INVENTORY SUPPLIES

Bossert is geared for both long and short production runs, and you can schedule your job to meet your normal operating requirements or seasonal peak loads without carrying a heavy inventory of parts.

SAVE ON SKILLED PERSONNEL

Bossert has the competent design engineers and experienced metal craftsmen to translate your ideas into cost-saving parts or assemblies. They can often suggest improvements that will make your product more attractive and less expensive to produce.

Large and small parts and assemblies in any metal or alloy . . .



This is a typical group of stampings and assemblies that we are currently producing. We often re-design parts that were formerly cast, forged or machined, at a substantial saving in cost.

Metal Stampings
BOSSERT

Send for illustrated booklet, "METAL STAMPINGS." It describes our design service and production facilities.

BOSSERT DIVISION
ROCKWELL SPRING AND AXLE COMPANY
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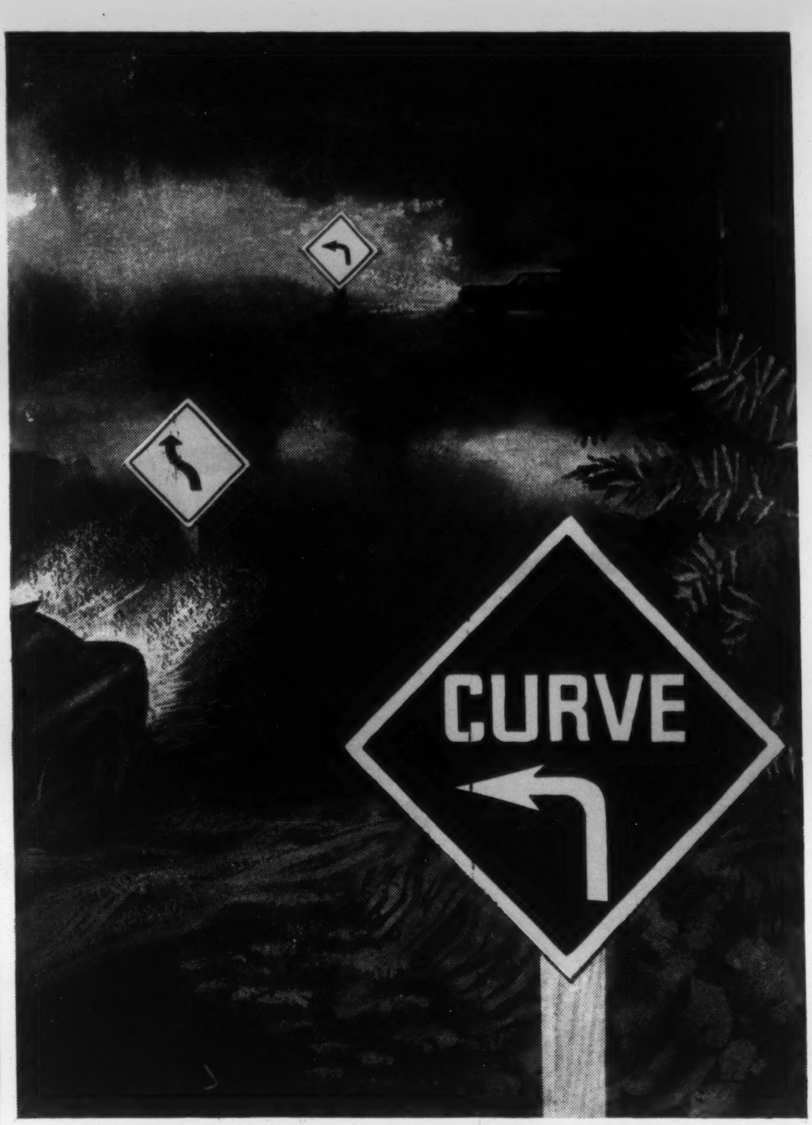

Foggy dew on 99 no problem for safety signs of GPX Plastic-Surfaced Plywood and "Scotchlite"

There's a bright future ahead for highway signs of GPX General Use and "Scotchlite" Reflective Sheeting as more and more states replace metal signs. Comparison proves that high density GPX Plastic-Surfaced Plywood actually deters moisture condensation and resists vandalism, sand etching, rain, or hail better than metal. GPX super-smooth surface is an ideal base for reflective sheeting at far lower cost. Don't take chances on safety signs that take chances on human lives . . . insist on GPX.

Free sample on request.

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Please send free sample and literature on GPX.

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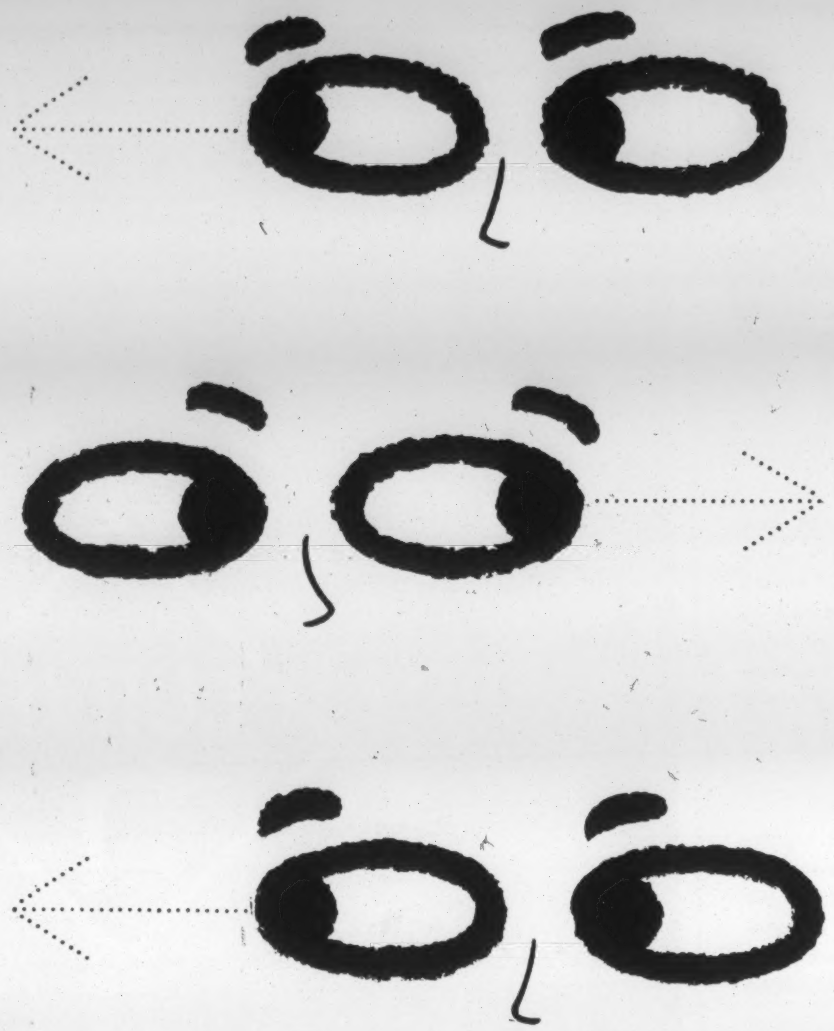
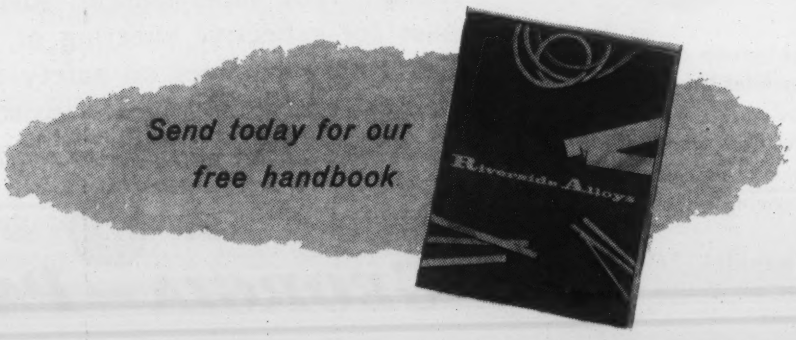


Alternating stresses bear watching!

Back and forth . . . up and down . . . in and out . . . if those stresses keep changing, the life of a metal part is a hard one . . . and often a short one. Stress reversals can cause "fatigue" failure at stresses far below the expected strength of the metal. One of the outstanding properties of phosphor bronze is its high resistance to fatigue failure. It is widely used for electrical switch parts, relay contact springs, bellows, rotating shafts and other moving or vibrating parts. For detailed information on phosphor bronze, write to Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N. J.



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HKP RIVERSIDE-ALLOY METAL DIVISION
H. K. PORTER COMPANY, INC.

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transparent conducting surface. When an alternating current is applied to the conducting surface, the phosphor ceramic dielectric emits a soft uniform glow over its entire surface. Its brightness depends on the voltage and frequency of the electrical field applied across the dielectric phosphor layer.

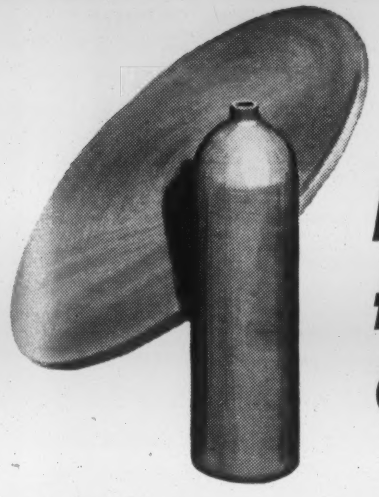
The company, though concentrating on supplying a lamp with low brightness, is trying to find ways and means to improve these lamps so that they may compete with other methods of general illumination.

Effect of Sulfur on Titanium Alloys

Data now available on the effects of sulfur additions on titanium alloys indicate some promise for alloys of titanium and sulfur. The effects of sulfur in sponge-base titanium, iodide-base titanium and various commercial and experimental titanium alloys were reported by L. W. Berger, D. N. Williams and R. I. Jaffee of Battelle Memorial Institute, in a paper presented at the 38th Annual Convention of the American Society for Metals.

Results of this study showed that:

1. Additions of up to about 0.025% sulfur result in considerable strengthening of titanium with a corresponding sharp decline in ductility. The initial sharp increase in strength occurs before sulfides are encountered in the microstructure and appears to be caused by solid-solution hardening.
2. Sulfur additions beyond 0.025% and up to 0.45% cause only a slight increase in strength and a slight decline in ductility.
3. Room temperature solubility of sulfur in titanium is between 0.009 and 0.017% by weight.
4. Thermal analysis and microstructure studies indicate little



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Higher Production Better Quality

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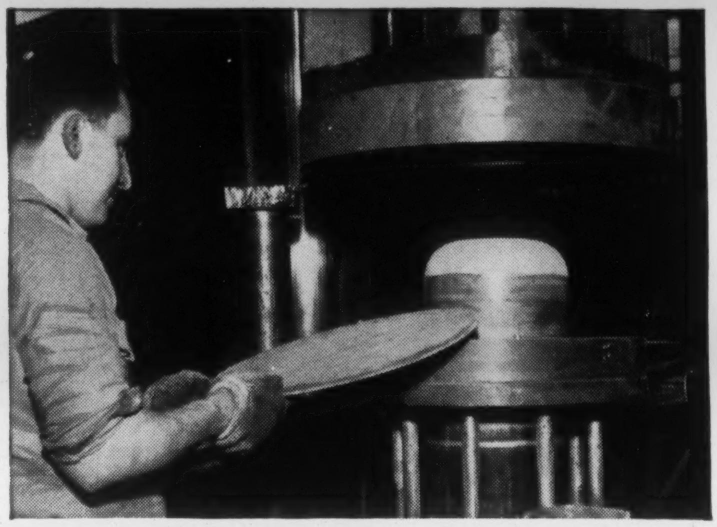
The Bonderite and Bonderlube combination provides effective lubrication and acts as a non-metallic parting layer between work and dies. More severe deformations are possible, reducing the number of press operations and process anneals necessary. Die life is lengthened and surface finish improved.

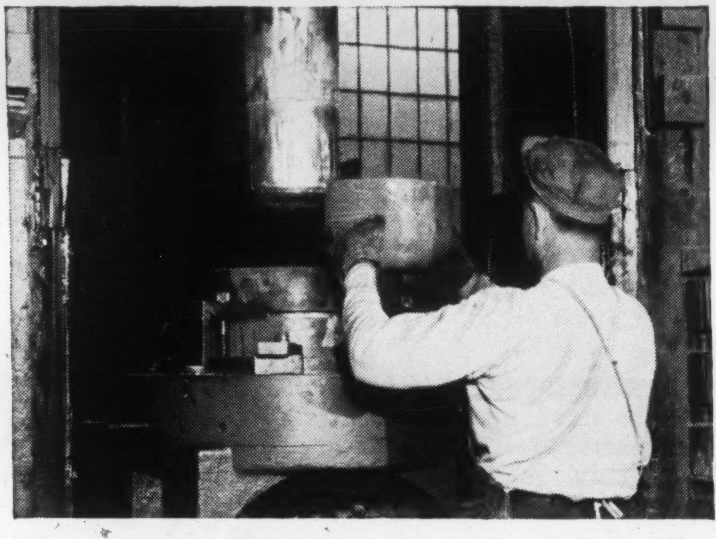
Bonderite and Bonderlube, by more efficient lubrication, help plants reach new production levels, get more efficient and economical production, and achieve better, more uniform quality.

Parker's cold forming experience in many plants and on many products is available to apply on your cold forming problems at once. Write or call today.

Bonderite as an aid in cold forming



Cupping: Flat CO_2 cylinder blank, treated with Bonderite and Bonderlube, is changed into cylindrical form, with maximum of about 45% reduction in diameter of blank.



First reduction: Diameter of cup is made smaller and length increased without major change in wall thickness.

Second reduction: Final diameter of part with respect to length determines number of reductions required. Photos courtesy NORRIS-THERMADOR Corporation, Los Angeles, California.

FREE TECHNICAL BULLETIN MAILED ON REQUEST

Illustrated technical bulletin "Bonderite and Bonderlube As Aids In Cold Forming" contains detailed information. Mailed free on letterhead request.

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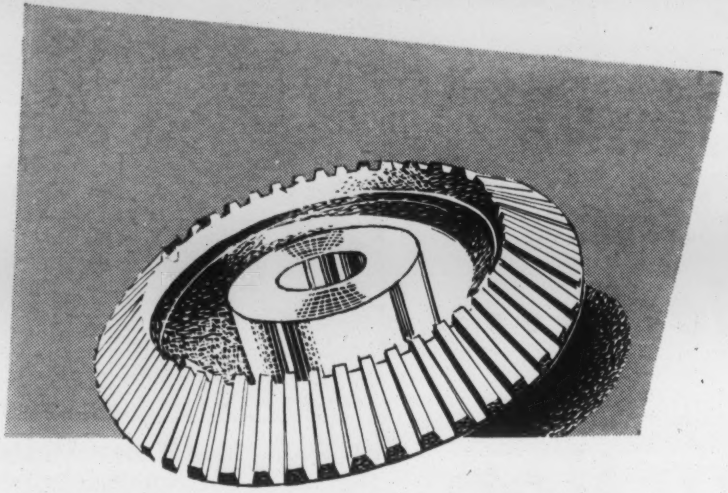
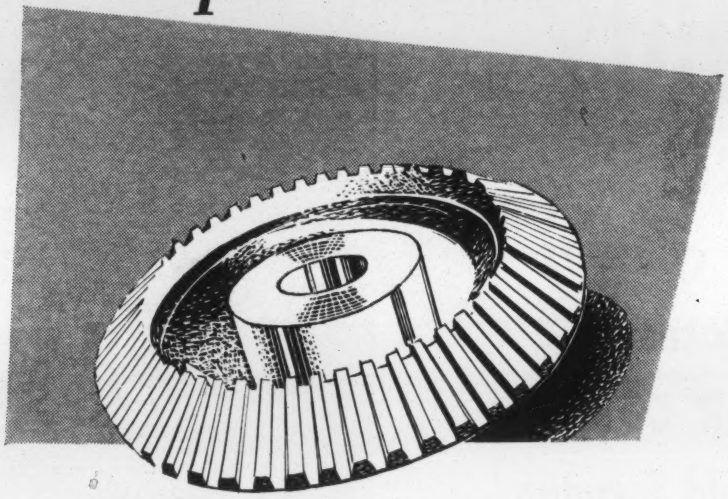
With Tensiles Over 100,000 PSI



one costs $31.21 per hundred



and one costs $22.51 per hundred

Why?

With reduced iron powders in both cases . . . the expensive compact derives its physicals from copper infiltration; the inexpensive compact from small additions of Metal Hydrides' chromium-nickel pre-alloyed powders. The comparative facts below show how you can achieve the physicals you need . . . in less than half the steps . . . at impressively lower cost with the MH process.

Copper Infiltration	MH Chrome-Nickel*
Cost — $31.21 per 100	Cost — $22.51 per 100
Tensile — 112,000 PSI	Tensile — 103,000 PSI
Elongation — 1%	Elongation — 2.5%
Rockwell Hardness — C34	Rockwell Hardness — C26
Apparent Density — 7.78	Apparent Density — 6.83
Production Steps — Nine	Production Steps — Four

*(7½% addition of 50% chrome/50% nickel, plus 1% carbon)

Without obligation our technical sales staff will gladly give you complete information and show you how chromium-nickel pre-alloyed powders will meet your requirements. Write today!

METAL HYDRIDES DIVISION

Metal Hydrides Incorporated

PIONEERS IN HYDROGEN COMPOUNDS

35 CONGRESS STREET, BEVERLY, MASSACHUSETTS

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effect of sulfur on the beta transus of titanium.

5. Sulfide networks are formed on casting in titanium containing as little as 0.25% sulfur and act as effective grain refiners. These networks may be broken up by subsequent working and annealing.

6. Additions of as little as 0.004% sulfur refine the grain size of both as-cast and wrought titanium; the maximum practical effect is obtained with about 0.05% sulfur.

7. Considerable grain growth occurs in sulfide-containing alloys on annealing for long times high in the alpha field, but only slight grain growth occurs on annealing in the beta field.

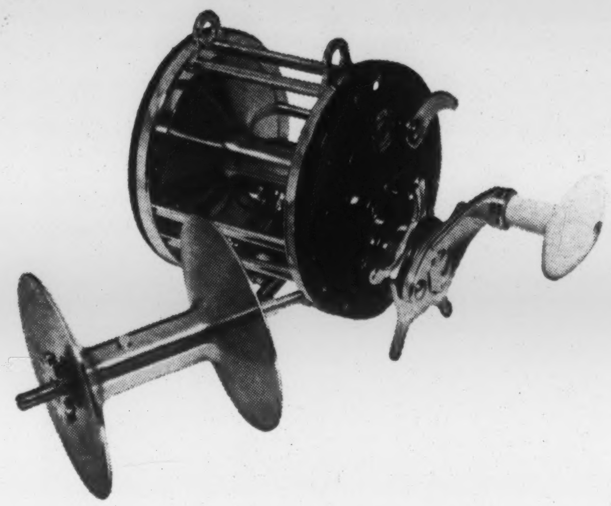
8. Additions of 0.2% sulfur to titanium alloys containing molybdenum, vanadium, or aluminum plus vanadium cause a considerable increase in yield strength with only a slight decline in ductility. This amount of sulfur was also sufficient to cause grain refinement in both the as-cast and wrought conditions.

New Ceramic Material Is Hard, Heat Resistant

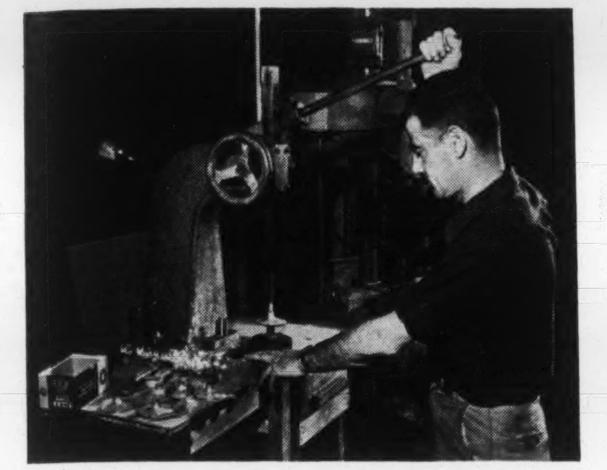
A hard, heat resisting ceramic material, called Hylumina, is now being made in England from a mixture of 95% finely milled aluminum oxide and 5% bonding and fluxing materials. The moist ceramic mix is readily molded into shapes that can be finished by milling or grinding. After firing in a kiln for some 33 hr at 2900 F, however, the material can be machined only with a diamond wheel.

Said to have good electrical, thermal and mechanical properties, the material is being used for spark plugs. It is serviceable at temperatures up to 2900 F and is resistant to all chemicals except hydrofluoric acid.

Reported to have a tensile



JOIN WITH HANDY & HARMAN SILVER BRAZING FOR PERMANENT PROFIT



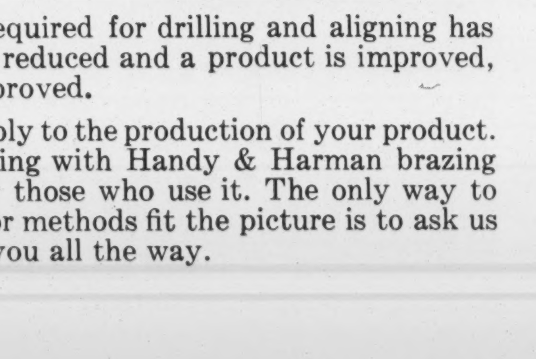
Inserting fluxed spindle and EASY-FLO silver alloy ring into lower half of spool. Assembly is completed when upper half of spool is pressed onto spindle. Press fit is necessary to maintain proper joint clearance between brass spool and steel spindle at brazing temperature.

This Yarn Has Fishermen Reeling ...With Absolute Confidence

Anybody who has ever caught a big fish knows the importance of a good reel. That's why manufacturers of fishing tackle are striving constantly for improvements in both design and production methods.

For example, when nylon line first appeared, Ocean City Manufacturing Company, the country's largest manufacturer of fishing reels, realized that the design of the reel spool would have to be changed. This because, with a big one on the line, the tremendous compressive forces of tightly wound elastic nylon often caused the spool flanges to spread so that the spool bound against the reel housing. Silver brazing with Handy & Harman EASY-FLO 45 silver brazing alloy and HANDY FLUX permanently and simply solved this serious problem.

Originally the spools were assembled from two fully machined brass forging halves with the hollow hub of each half fitted over a solid steel spindle with the drive clutch at one end. Each half was secured with 3/16″ stainless steel pins driven through the spool hub into the internal spindle.

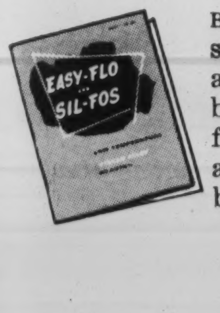


The same spool components are still used except that now semi-machined brass spool halves are silver brazed directly to the steel spindle with a preplaced ring of EASY-FLO 45 alloy. The shear strength of the brazed joint now exceeds 40,000 psi and because of the greater area of adherence to the spindle (as compared to two stake points previously used) spool hub creep toward the spindle ends is eliminated. The alloy cost is only 1.3 cents. The assembled spool is now finish-machined as a unit. The machining time once required for drilling and aligning has been eliminated. And when time is reduced and a product is improved, costs are reduced and sales are improved.

These same benefits could easily apply to the production of your product. The simple fact is that silver brazing with Handy & Harman brazing alloys has paid off handsomely for those who use it. The only way to find out if and how your product or methods fit the picture is to ask us —we'll be delighted to work with you all the way.

Sliding burner assembly into heating position. Weight of upper platen assures accurate joint fit when ring of EASY-FLO alloy melts. Fuel is mixture of city gas and oxygen. Operator brazes 20 to 30 spools per hour.

TO HAVE AND TO HOLD



BULLETIN 20 tells you why high strength, speed and economy are inherent in EASY-FLO silver brazing. Also gives Handy information about joint design and fast brazing methods. We'll be pleased to send you a copy.

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determine carbon potential

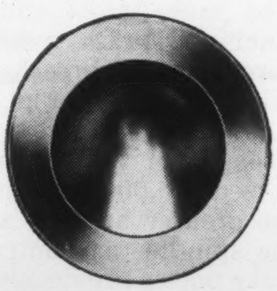
detect
- restricted flow of atmosphere
- leaky furnace seals
- transient moisture and air from quench tank
- air carried into the furnace with the charge

with the DEWPOINTER

Quick and accurate readings of dewpoints in each furnace zone give the heat treater the most valuable information possible for accurate adjustment of furnace atmosphere.

In one relatively inexpensive unit, the Dewpointer brings you this accurate data with simple operations. Any shop man can get precise readings every time—for the maximum in effective furnace control.

Only the Alnor Dewpointer gives you controlled test conditions...indications take place in an enclosed chamber. Dew or fog is suspended in the air as sunbeams —not on a polished surface. This unique principle gives you the greater accuracy, faster readings required for critical heat treating atmosphere control.



Eliminate Guesswork
Here's what you actually see with a Dewpointer—a swirl of sunbeams that is unmistakable in reading. Find out why so many use the Dewpointer for atmosphere control. Send for your copy of the illustrated Dewpointer Bulletin. Write: Illinois Testing Laboratories, Inc., Dept. 522, 420 North LaSalle Street, Chicago 10, Ill.

Alnor

ILLINOIS TESTING
LABORATORIES, INC.

For more information, turn to Reader Service Card, Circle No. 492

strength of 172,000 psi and a compressive strength of 316,000 psi, the material is recommended for plug gages; nozzles for sand and shot blasting; guides in textile spinning and weaving machinery; guides, pulleys and spindles for hot wire tinning baths; creep testing rigs; induction heating equipment; and as a replacement for glass in sealed electrical assemblies.

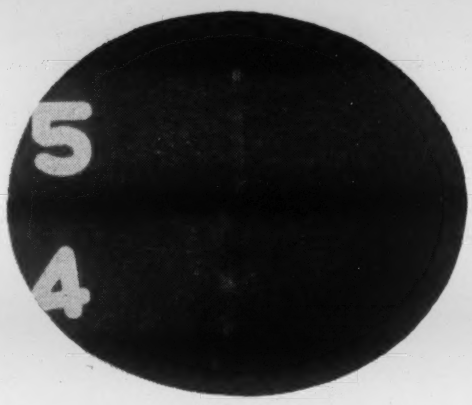
(Condensed from *European Technical Digests*, Dec '56

Epoxy-Base Liner Is Oil Resistant

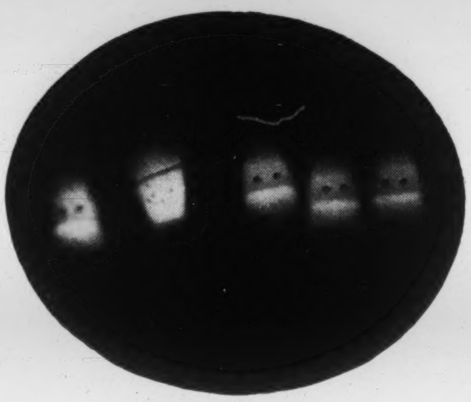
Homalite Corp., 11-13 Brookside Dr., Wilmington 4, Del., has introduced an epoxy-base liner for use on tanks, scrubbers, steamers, columns and ducts. The two part plastics compound, called Coroline 347, hardens in approximately 24 hr at ambient temperatures and does not require high temperature cures.

It is particularly recommended for use with petroleum products, and is resistant to organic acids, dilute mineral acids, alkalies and most solvents. It is claimed to have good adhesion, and can be applied by brush or spray to com-

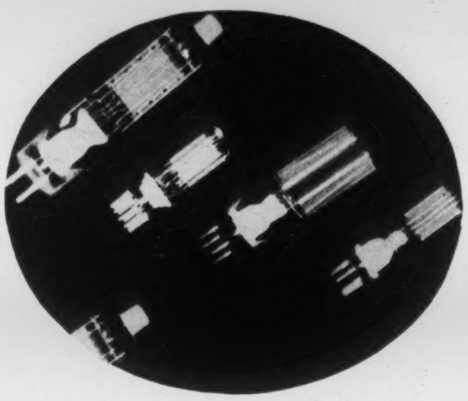
Plastics lining *material is brushed on the inside of a tank.*



BANDSAW BLADES... *radiography discloses defective fusion of butt-welds joining the band*

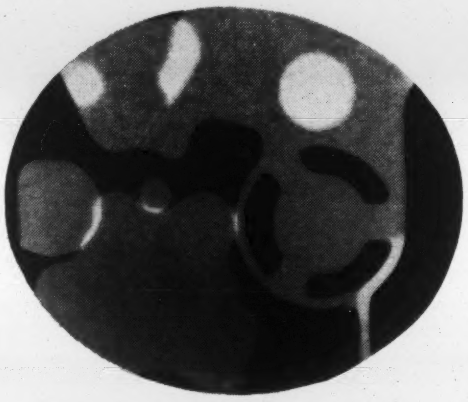


ARTIFICIAL DENTURES . . . *radiography discloses "cavities" in cast plastic teeth due to air bubbles*



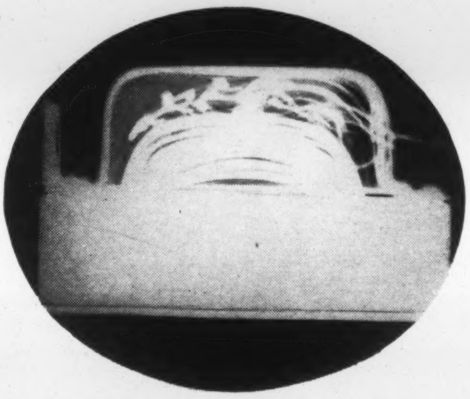
ELECTRONIC TUBES... *radiography discloses misalignment of hidden elements, broken wires*

are YOU in this Profit-Picture?

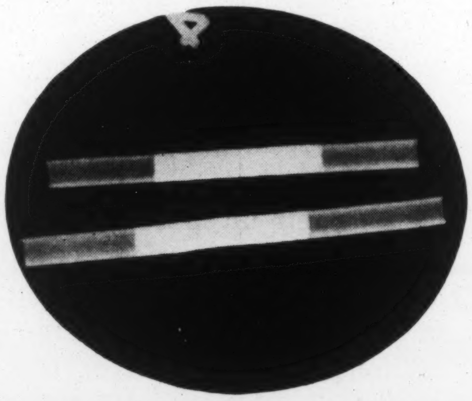


ALUMINUM CASTINGS . . . *radiography discloses intergranular shrinkage of a high-stressed part: averts predictable failure*

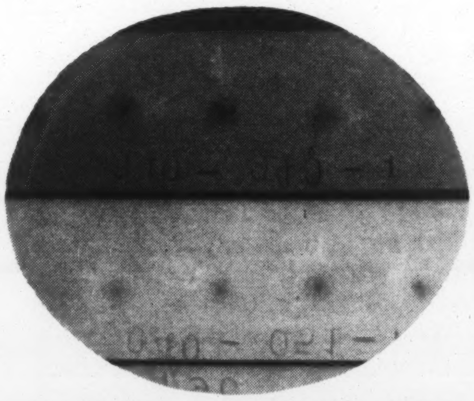
Here's a random sampling of the growing *diversity* of products being quality-controlled by radiographic inspection. Manufacturers find this *nondestructive* method quick, decisive – above all, *profitable.*



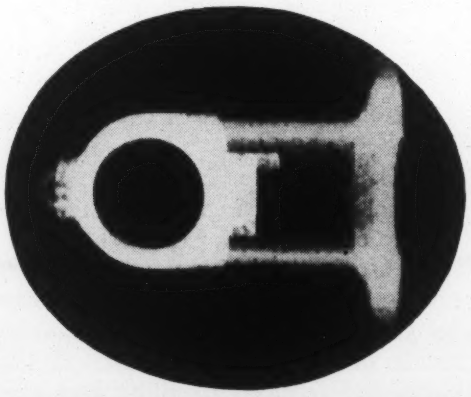
HOUSED ASSEMBLIES . . . *radiography checks alignment of hidden components as in this TV transformer*



FUEL ELEMENT TUBES . . . *radiography and fluoroscopy uncover defects in critical welds of dissimilar metals*



SPOTWELDS... *radiography pilot-checks accuracy of welding technics, inspects production welds for soundness*



MAGNESIUM CASTINGS . . . *radiography detects honeycomb porosity in a gasoline engine intake manifold*

find out what radiography can do for you . . .

Simply call in your local Picker representative* or write us outlining your problem (and if possible sending typical samples). We'll make tests and tell you frankly whether radiography holds any promise for you. Because Picker offers *both* x-ray and isotope equipment, we have no axe to grind for any particular unit.

Costs you nothing to find out . . . maybe it's costing you a great deal right now *NOT TO.*

Picker x-ray

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**There's probably a Picker district office near you (see local 'phone book).*

Picker ... one Stop for Everything in Radiography and Fluoroscopy

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WHO USES MAGNESIUM?
...and why

Look for the product that's out front in its field . . . and you know *who* uses magnesium! Why? . . . because design engineers and manufacturers alert to today's market conditions are quick to realize the added sales advantages of the product *made of magnesium.* Lightest of the world's structural metals, magnesium can be cast, formed, extruded, drawn or worked into virtually any size or shape! A *modern* metal in every sense, its lightness, strength and weight-saving characteristics are without equal. Even more important are the cost-savings to be gained in many areas of manufacture. The use of magnesium frequently results in *lowered* tooling costs—savings in machining, fabrication and processing costs—and reduced handling and assembly costs!

Magline Inc. has assisted many leading companies in developing better products through the application of magnesium. Magline engineers are qualified by years of experience in this specialized field, and can assist you with design and technical problems. Magline facilities are extensive and complete—from foundry . . . to fabrication . . . through final assembly! For quality production—short or long runs —you can depend on Magline for prompt service and delivery.

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- Forming
- Machining
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foundry facilities for
- Sand Castings
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For more information, turn to Reader Service Card, Circle No. 391

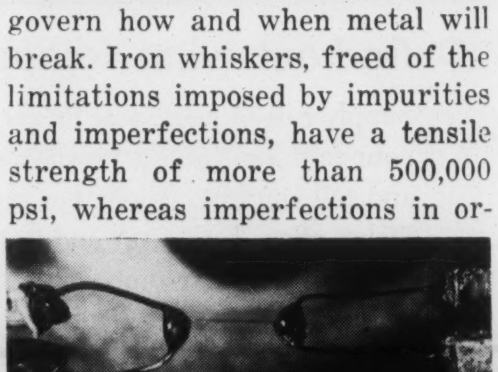
plex surfaces and hard to reach places. When more than one coat is required successive applications can be made immediately. The epoxy-base lining material can also be used to apply glass cloth and other fabrics to tanks, bins and ducts.

Technique Measures Forces Between Atoms

A technique for pulling apart tiny crystals of iron and silicon and measuring directly the applied stress and amount of strain they undergo may help scientists gain new insight into the enormous forces that bind atoms together.

During the seventh New York meeting of the American Association for the Advancement of Science, Dr. R. L. Eisner, Westinghouse research physicist, said "use of the method has cast new light on the nature of the interatomic forces which give all metals their ultimate strength."

The research physicist said that metal exists in perfect condition in single crystal whiskers (40 millionths of an inch or less in diameter), whereas ordinary metal contains countless millions of structural imperfections. These imperfections, when under stress, govern how and when metal will break. Iron whiskers, freed of the limitations imposed by impurities and imperfections, have a tensile strength of more than 500,000 psi, whereas imperfections in or-



Interatomic forces *in an iron crystal whisker are measured in a device by stretching the tiny strand of metal almost to the breaking point.*

How to cut your wire-handling costs

You might be surprised at how much you can trim your costs with better methods of handling steel wire. For example, we often find that when coils of wire are unloaded in customers' plants they are simply piled on the floor. This wastes valuable floor space, and clutters the aisle. And moving the wire along to the production line becomes a headache.

One customer's excellent solution to the wire-handling and storage problem is shown above. The racks, built largely from steel pipe, more than triple the storage capacity of the floor area. Coils are out of the way, yet they're easily moved by lift truck.

Another customer wanted to avoid shutting down his cold-heading machines every time a coil of wire was used up. We showed him how to set up the wire coils on two pay-off reels so that no interruptions were necessary when one coil was welded to the other.

Users of wire in large coils often have a handling problem. In working out practical handling methods for extra-heavy coils, we try to help the customer avoid the nuisance and expense of returning pallets or containers.

Because we handle so much wire in our own plants, we have developed a lot of time-saving methods which we're glad to pass along. And we're ready to do more than just offer general suggestions. If you wish, we'll provide you with drawings and specifications for such things as pipe racks, pay-off reels, and other equipment that may help you to cut your wire-handling and storage costs.

Our main job is to make top-quality steel wire to meet a wide range of requirements. But our service goes far beyond simply taking your order and shipping the wire. So don't hesitate to call our nearest sales office if you have a wire problem.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

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to improve your products!

Bring out the lion in your products—exploit their potentialities with plastisol-organisol applications. And do it the surest way by coating with REYNOSOL. Reynolds supplies or custom-formulates Reynosol with characteristics "to order" . . . in colors of your choice . . . for your products of metal, glass, fabric, paper, wood! And we work right along with you—so you get the really special service, technical experience and know-how . . . the research and consultation needed to give your products extra "punch"! To hear how we do it, write today.

Dept. A

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REYNOLDS CHEMICAL PRODUCTS COMPANY
ANN ARBOR, MICHIGAN
DIVISION OF STUBNITZ GREENE CORP.

For more information, Circle No. 542

dinary steel cause it to flow and deform at one-tenth its ultimate strength. Even the elastic limit of a soft metal such as tin in the perfect structural state is at least ten times the maximum of the best steels in common use today.

How whiskers are tested

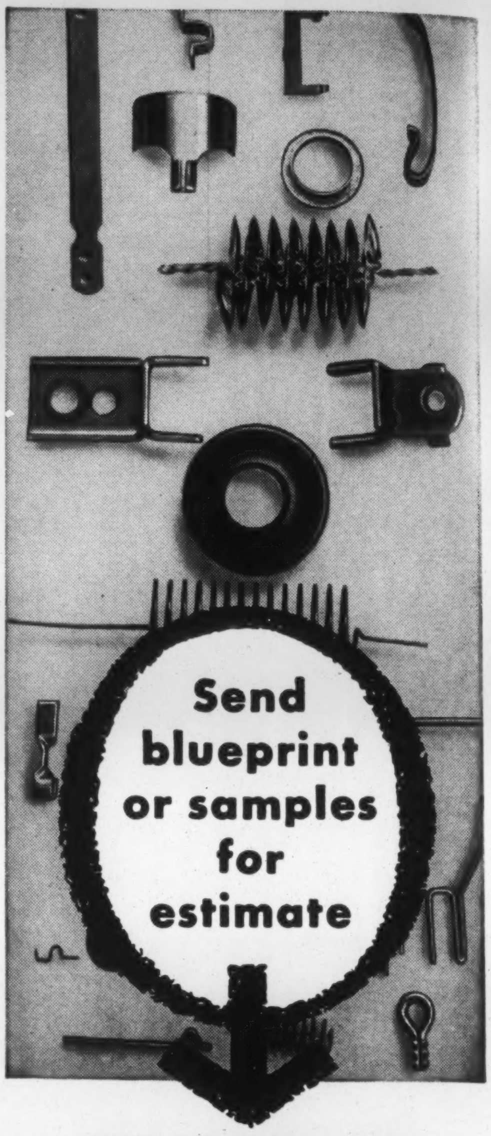
A small force, less than 0.01 oz, is required to pull an average whisker apart. This force is obtained by using the whisker to pull a lightweight pendulum from its vertical rest position. Each millionth of an ounce of pull displaces the pendulum exactly the same amount, about 0.0001 in.

Stretch of the tiny whisker is measured by reflecting a beam of light from flat optical mirrors attached to clamps at each end of the whisker. As the whisker stretches, the mirrors move and cause changes in the pattern similar to the changing rainbow colors seen in soap bubbles. The changes are then electronically amplified and analyzed to disclose the amount of stretch. The technique accurately measures changes in whisker length within less than one-millionth of an inch.

Dr. Eisner says scientists are beginning to understand the origin of the interatomic forces which glue atoms so tightly to one another. Experiments on the very simplest metal atoms will give additional data that will verify theoretical conclusions—a necessary first step toward eventual use of this knowledge in developing new and better metals.

Aluminum-Clad Wire Resists Oxidation, Heat

An enameled, aluminum-clad copper wire that combines good electrical conductivity with heat and oxidation resistance has been introduced by Westinghouse Electric Corp. The wire is encased in



WIRE FORMS and METAL STAMPINGS

We'll prove that our high speed production means lower unit costs for you!

You'll save two ways — (1) the initial low unit cost made possible by high speed machines; (2) precision and quality control guarantees accurate parts and performance.

STRAIGHTENING AND CUTTING
Perfect straight lengths to 12 feet.
.0015 to .125 diameter.

WIRE FORMS
.0015 to .125 diameter.

SMALL METAL STAMPINGS
.0025 to .035 thickness.
.062 to 3 inches wide.

Specializing in production of parts for electronic, cathode ray tubes and transistors.

Write for illustrated folder.

ART WIRE AND STAMPING COMPANY

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For more information, Circle No. 448

TODAY'S NEW AUTOMOTIVE DESIGNS DEMAND THE BEST STEEL OBTAINABLE

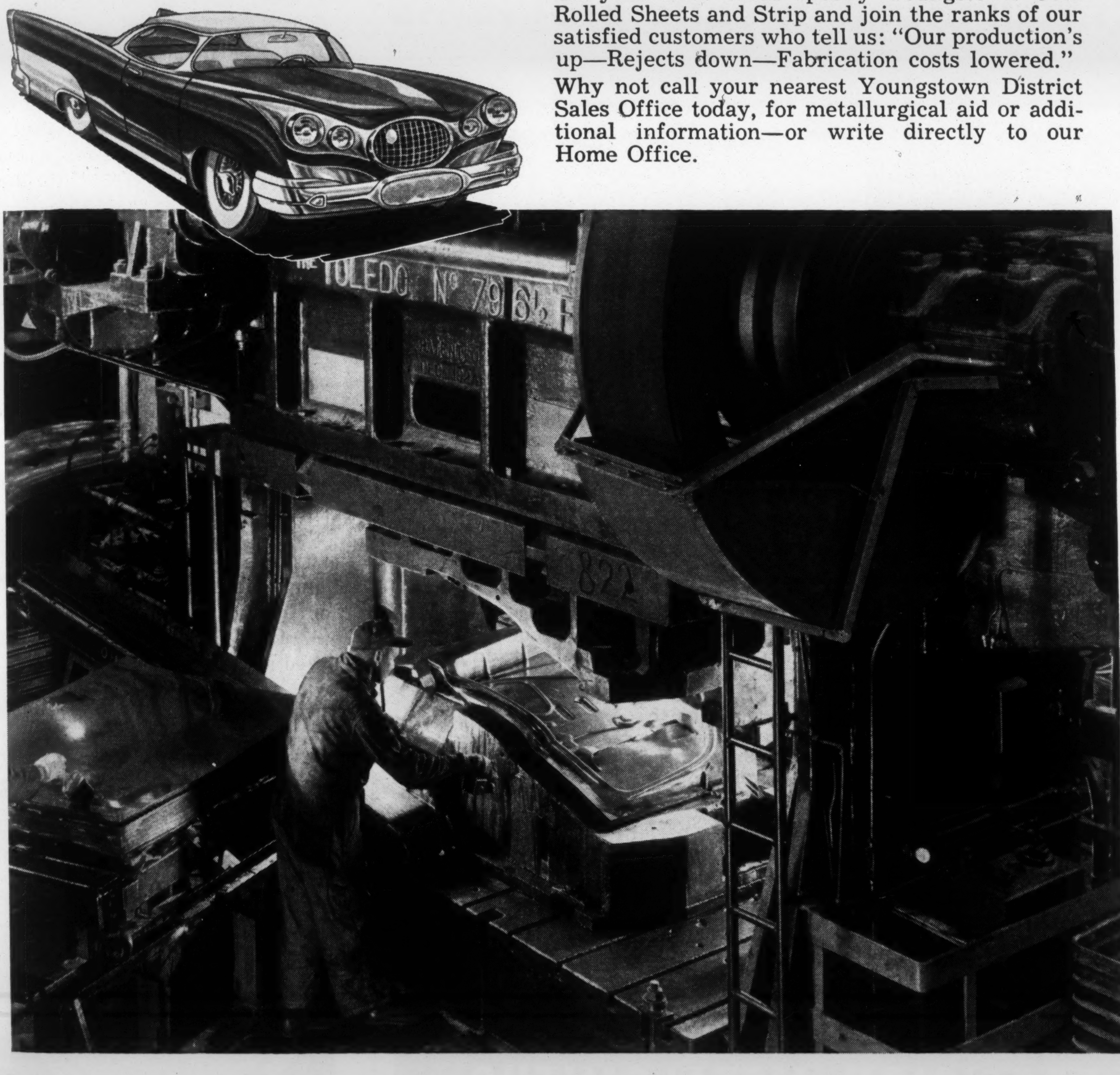
Youngstown Sheets and Strip

Detroit's high-speed automobile body presses are busier than ever turning out body components for today's modern-design cars. More intricate door and fender sections of the new models demand a steel of the highest quality that can take the required deeper draws in its stride. Without question, that steel is Youngstown Cold Rolled Sheets and Strip—the best available anywhere.

Youngstown blends the required combination of surface finish, tensile strength and ductility into every sheet, to provide you almost continuous pressings of even the most difficult-to-form parts. Also, metallurgical quality never wavers from Youngstown's high standards because all operations from ore mining to shipping dock are rigidly quality-controlled by experts with over half-a-century of steelmaking know-how.

On your next order specify Youngstown Cold Rolled Sheets and Strip and join the ranks of our satisfied customers who tell us: "Our production's up—Rejects down—Fabrication costs lowered."

Why not call your nearest Youngstown District Sales Office today, for metallurgical aid or additional information—or write directly to our Home Office.



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General Offices - Youngstown 1, Ohio
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Producers of Quality Carbon and Alloy Steels for Over Half-a-Century

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QUALITY
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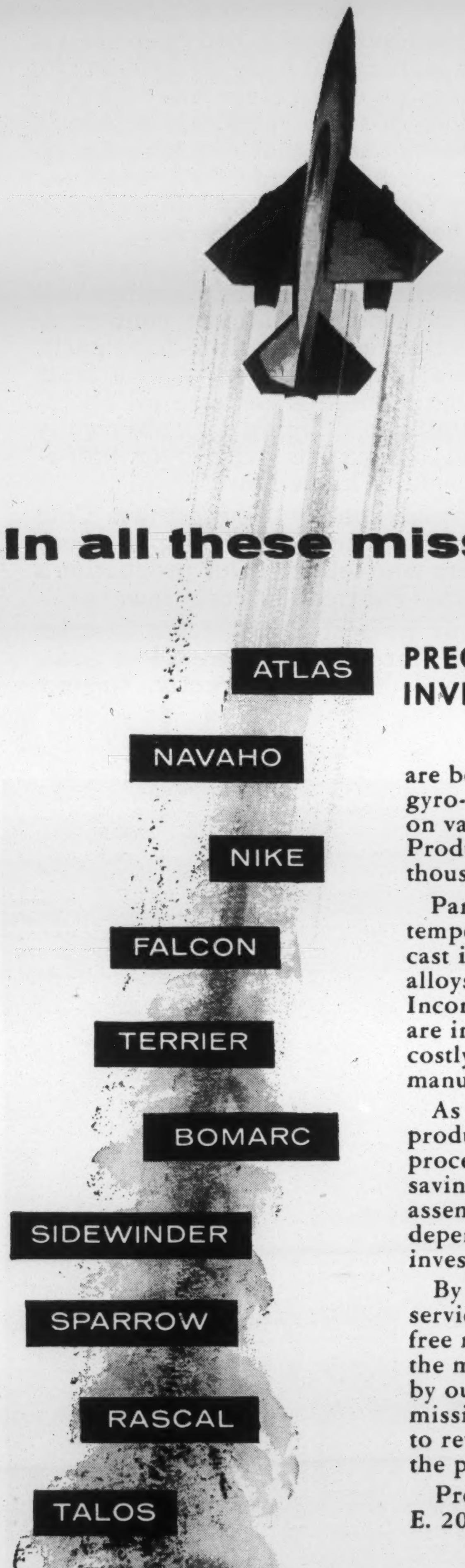

In all these missile programs

ATLAS
NAVAHO
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TALOS

PRECISION METALSMITHS' INVESTMENT CASTINGS . . .

are being used in the power plants, gyro- and servo-mechanisms, and on various other types of equipment. Production orders may run into thousands of pieces or as few as desired.

Parts that must resist the terrific temperatures encountered are being cast in the excellent heat-resistant alloys like Hastelloy, Stellite and Inconel. Ferrous and non-ferrous alloys are investment cast in shapes too costly to fabricate by other manufacturing methods.

As a result of using this process for producing a part, the fabrication process is simplified and sizable cost savings are made. In contrast with assemblies, greater uniformity and dependability are often obtained with investment castings.

By taking advantage of our prototype service, the product designer can give free rein to his imagination. To get the most out of your designs and profit by our extensive experience on these missile programs, ask our engineers to review them while they're still in the planning stage.

Precision Metalsmiths, Inc., 1077 E. 200th Street, Cleveland 17, Ohio.

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See us at Booth #742

pour yourself an assembly with
PRECISION METALSMITHS INC.
INVESTMENT CASTINGS

For more information, turn to Reader Service Card, Circle No. 518

What's new IN MATERIALS

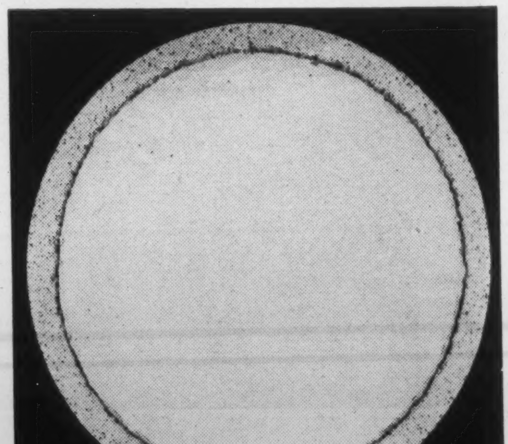
an aluminum "skin", 0.0025 in. thick, to which is added a layer of high temperature insulation.

It had been found previously that copper wire, at high temperatures, unites chemically with the oxygen in the air to form a layer of copper oxide on the surface. This layer gradually grows in depth, degrading the insulation.

The oxide formed on the surface of aluminum, on the other hand, does not grow appreciably. In a film about four ten-millionths of an inch thick (0.0004 mil), aluminum forms a self-protecting coating which prevents further penetration of oxygen and effectively isolates copper wire from attack by oxygen. The aluminum film is kept as thin as possible because aluminum is a poorer electrical conductor than copper and lowers the current-carrying capacity of the wire.

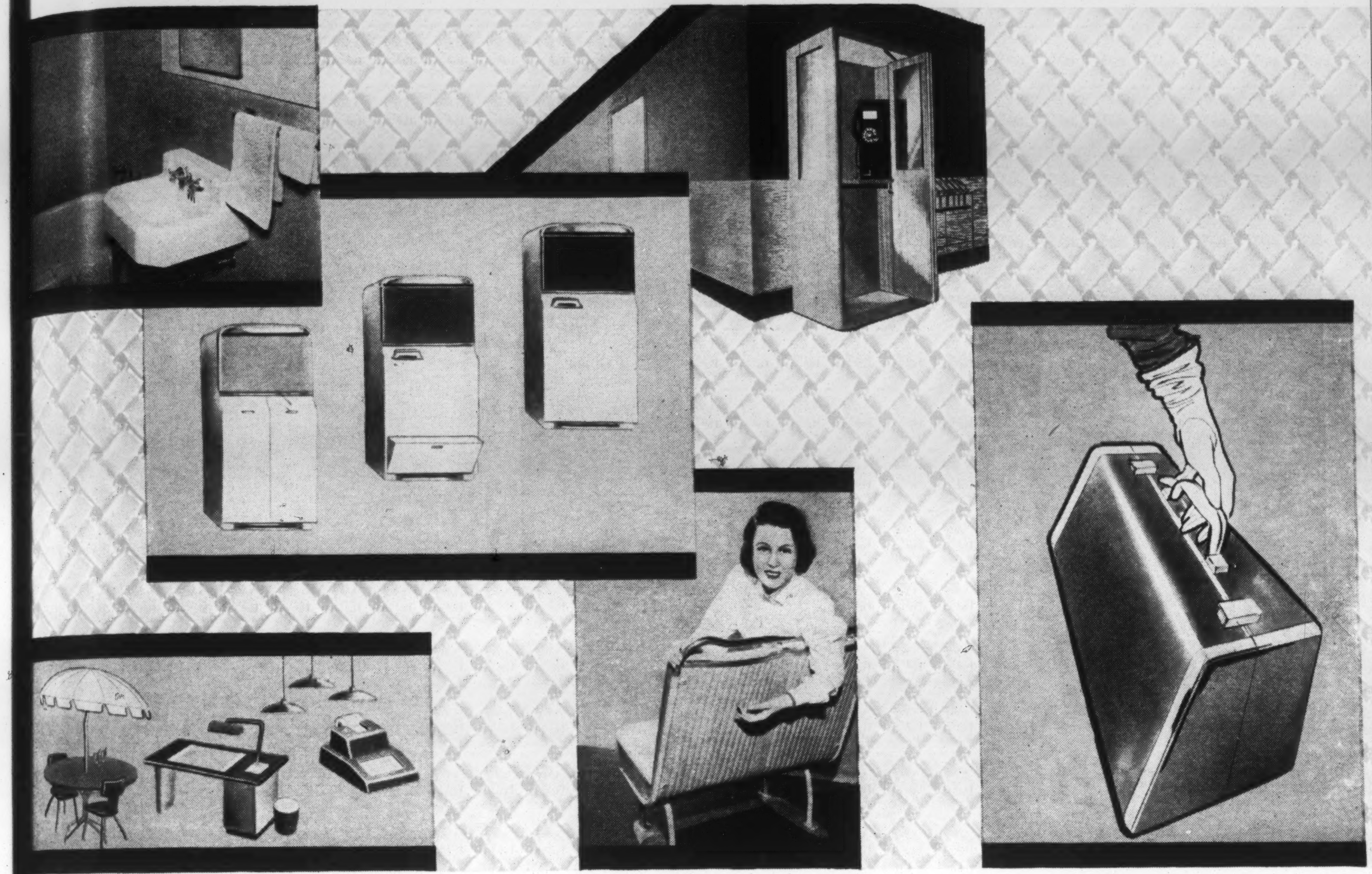
In making the wire, the copper rod is first plated with a layer of silver, which acts as a barrier to the interaction of the two metals and allows proper adhesion. The silver plated copper rod is inserted into a thin-walled tube of aluminum and rolled into a rod of smaller diameter, then drawn through dies into wire of the desired size and shape. The finished wire is coated with a high temperature insulating enamel.

(more What's New on p 216)



Cross section *of aluminum-clad copper wire showing copper core, silver layer and aluminum cladding.*

Naugatuck Marvibond



Marvibond*... the vinyl-to-metal laminating process that provides all these advantages...

- available in flat sheets
- worked with standard metal-fabricating tools
- can't chip, crack, or craze
- eliminates costly finishing operations
- can't rust, rot, or corrode
- wipe-clean vinyl, easy to maintain
- attractive colors, practically any surface effect
- always comfortable, pleasant to the touch

Marvibonded metals are laminated in flat sheets before the product is formed. However, neither finish nor bond is affected by bending, crimping, drilling, embossing, punching, or shearing.

Marvibonded metals provide your product with a "sales wise" finish far superior to paints, lacquers, varnishes, phenolic and alkyd finishes. The vinyl will not chip, crack, or craze. Practically any surface effect can be achieved, economically, and they're all chemical-, abrasion- and weather-resistant.

This exceptional material has a great future in wall paneling, doors, vending and business machines, office furniture and automobile interiors ...in fact, where most sheet metal is used. For samples, technical information, and the location of licensed laminators in your area, please write us on your company letterhead.

*Patent applied for

For more information, Circle No. 534

United States Rubber

Naugatuck Chemical Division

Naugatuck, Connecticut

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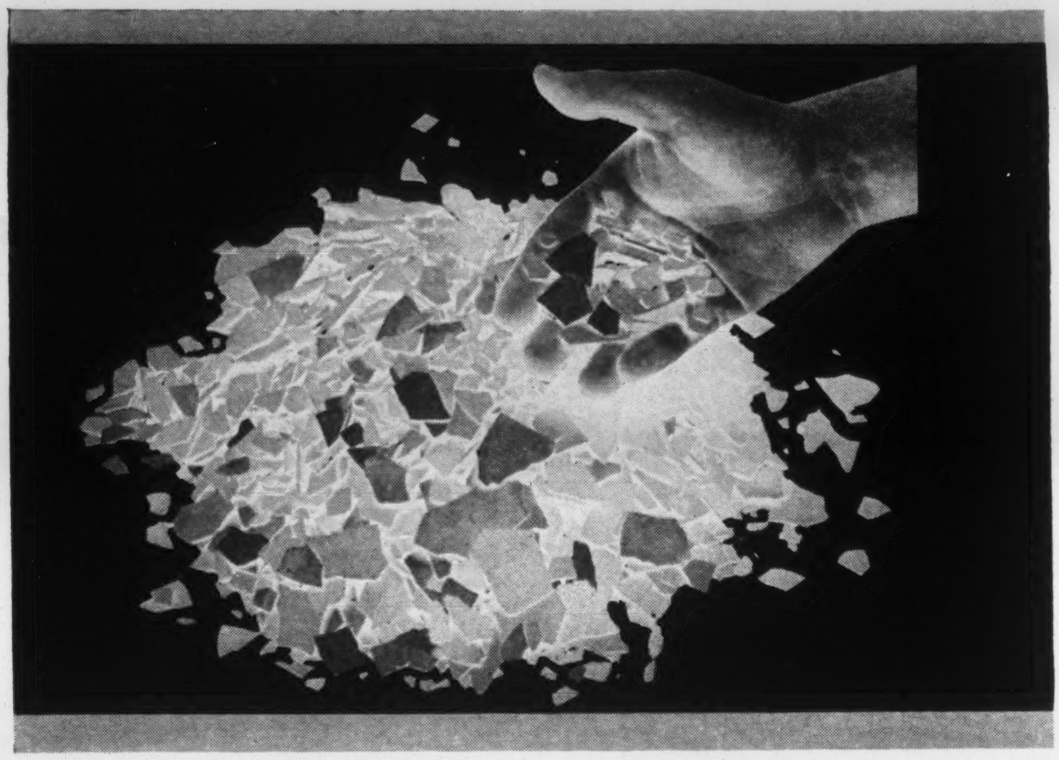
new . . . booming . . . stainless steels
call for alloy purity



and ELECTROMANGANESE® has it

Lower cost . . . better mechanical properties . . . and improved appearance are giving tremendous impetus to the new high-manganese stainless steels. Best of all, for those who have been working in the old high-nickel alloys, the new 200 Series requires no change in production operations, and possibly effects some savings.

But—high manganese content means *pure* manganese . . . electrolytic manganese. Most of the new alloys cannot tolerate more than a trace of carbon, phosphorous, or lead. Foote Electromanganese, with 99.98% manganese content, gives you this purity. Hydrogen is as low as 150 ppm, and even this can be reduced to 7.5 ppm in a *Hydrogen-Removed* Grade. Nitrided manganese is available in Foote's high-purity Nitrelmang®. But just as important as purity, and as a direct result of it, these Foote alloying agents enable you to get the necessary manganese content in the most economical way.

If you want to exploit these promising new steels, one of our engineers will be glad to contribute Foote's knowledge of more than 17 years experience in electrolytic manganese alloying. A letterhead request will bring information promptly from our Technical Literature Department, Foote Mineral Company, 408 Eighteen West Chelten Building, Philadelphia 44, Pa.

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ELECTROLYTIC MANGANESE METAL • WELDING GRADE FERRO ALLOYS • STEEL ADDITIVES
COMMERCIAL MINERALS AND OXIDES • ZIRCONIUM & TITANTIUM • (IODIDE PROCESS)
LITHIUM METAL, CHEMICALS, AND MINERALS • STRONTIUM CHEMICALS

For more information, turn to Reader Service Card, Circle No. 583

What's new IN MATERIALS

Causes and Prevention of Magnesium Fires

Most magnesium fires can be prevented by proper care but some causes of fire are not easy to avoid. In a paper presented at the 38th Annual Convention of the Magnesium Assn., Frederick W. Roberts of Dictaphone Corp., discussed some of the problems his plant encountered and how they were overcome.

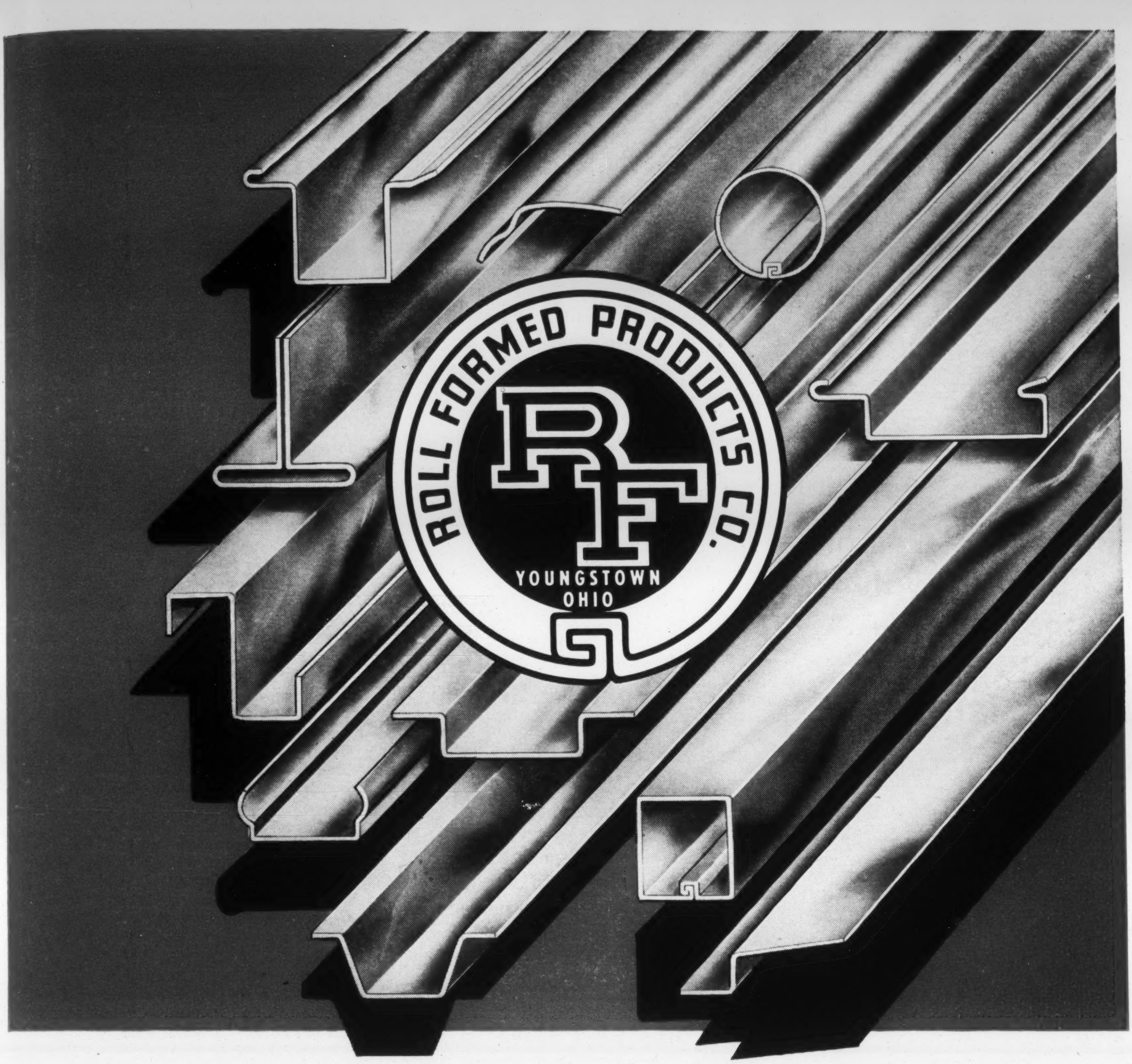
The first fire due to magnesium occurred when sand cast magnesium motor bearing supports were being turned. It is believed that the tool struck a sand inclusion in the casting and caused a spark which in turn started the magnesium burning. This problem was alleviated by replacing the sand castings with die castings.

A second fire resulted from carelessness. In sanding, the belt of the sanding machine becomes loaded with magnesium powder, and posted rules state that only magnesium may be sanded on this machine. However, an operator inadvisedly started to sand a piece of steel and caused an explosion.

Some fires that occur in milling operations seem to be beyond the control of the fabricator. In milling die castings, the carbide tipped gang milling cutter occasionally strikes inclusions of magnesium nitride, and the resulting sparks start a fire. This problem has not been solved.

Zinc-Clad Aluminum Improves Soldering

Available for the first time in commercial quantities is a zinc-clad aluminum alloy that is expected to help solve many joining problems, especially in the auto radiator field. Developed by *Aluminum Co. of America*, 1501 Alcoa Bldg., Pittsburgh 19, and called Alcoa Soldering Sheet, the ma-



REDUCED COSTS

BY REDESIGN OR ADAPTING TO ROLL FORMED METHOD

Roll forming method is truly the automation of the stamping industry—many individual press operations are combined in a continuous production procedure. In many instances redesign is not necessary to permit production by the roll formed process, but where redesign is required our staff of qualified expert engineers are available at all times to assist you in the engineering work needed.

The old trite saying "It pays to investigate" surely applies in this case. At no cost to you, submit your inquiries, and we will do the rest.

Utilizing our advanced facilities and know-how can only result in a more exact dimensioned part and a reduction in your cost.

Contact your nearest Roll Formed representative or write **Roll Formed Products Company, Youngstown, O.**

Ask for Catalog No. 1555

ROLL FORMED PRODUCTS
COMPANY

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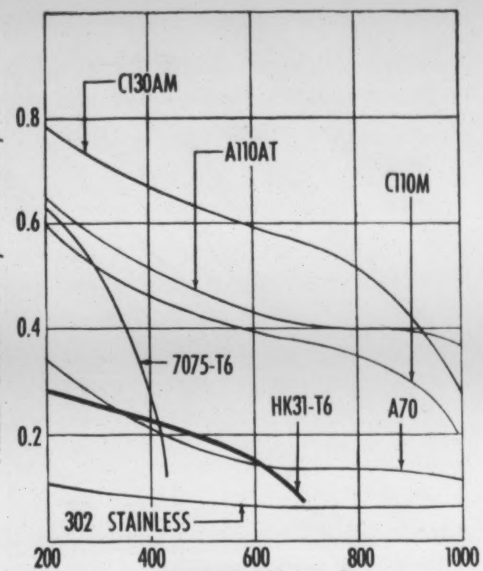
For more information, turn to Reader Service Card, Circle No. 431

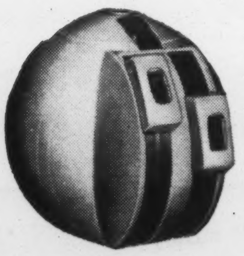


Yield strength, weight vs. temperature.

For High Strength-to-Weight Ratios at Elevated Temperatures— TITANIUM and MAGNESIUM

The experience, the specialists, the equipment-and-facilities to design and produce the *very difficult* fabrication and assembly work in these and other light metals—you'll find at B&P.

To make this titanium pressurized tank, B&P welds two cylinders. Each is drawn in one operation. Tank withstands 5000 psi pressure



Magnesium turret enclosure for a bomber. Design, lofting, prototypes, production fabrication and assembly are all done by B&P.

ENGINEERING FACILITIES IN DETROIT AND LOS ANGELES . . Write for Titanium and Magnesium engineering data—also folder on B&P's facilities to handle tough jobs.

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Phone: STanley 7-9665

56 A

OFFICES IN NEW YORK, WASHINGTON, DALLAS

For more information, Circle No. 486

terial is said to bring aluminum within range of the ease of solderability of copper. It is also said to simplify normal maintenance and repair problems of soldered assemblies and reduce costs of production methods.

The zinc-clad aluminum, fabricated with one or both sides clad, is available in both coil and flat sheet form. The company recommends that it be used with specially developed soldering techniques.

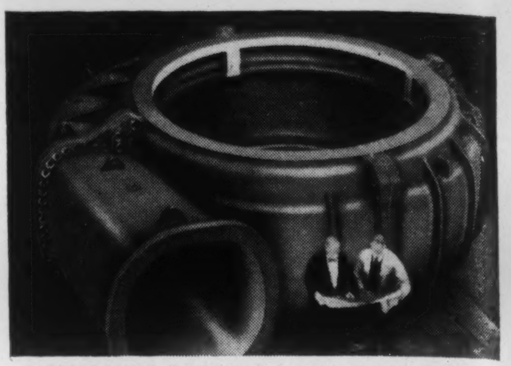
Polyester Sheet Has Chromium Finish

A line of high strength, metallized plastics sheets has been announced by *Coating Products Co.*, 101 W. Forest Ave., Englewood, N. J. The plastics sheets are unsupported Mylar film with a high luster chromium finish and backed with pressure sensitive adhesives for nonmoisture applications.

Called Mirro-Brite, the nontarnishing sheets are 0.001 in. thick and measure 20 x 25 in. Other sizes are available on request. The metallized sheets are recommended for display and decorative items for either indoor or outdoor use.

How Fatigue Cracks Affect Aluminum Alloys

Since aluminum has no endurance limit, fatigue cracks are practically inevitable when aluminum aircraft structures are subjected to high stresses. It is therefore essential that the designer have information regarding the remaining strength of parts containing such cracks. An investigation to determine the static strength of aluminum alloy specimens containing fatigue cracks has been conducted by Arthur J. McEvily, Jr., Walter Illg and Herbert F. Hardrath, of Langley



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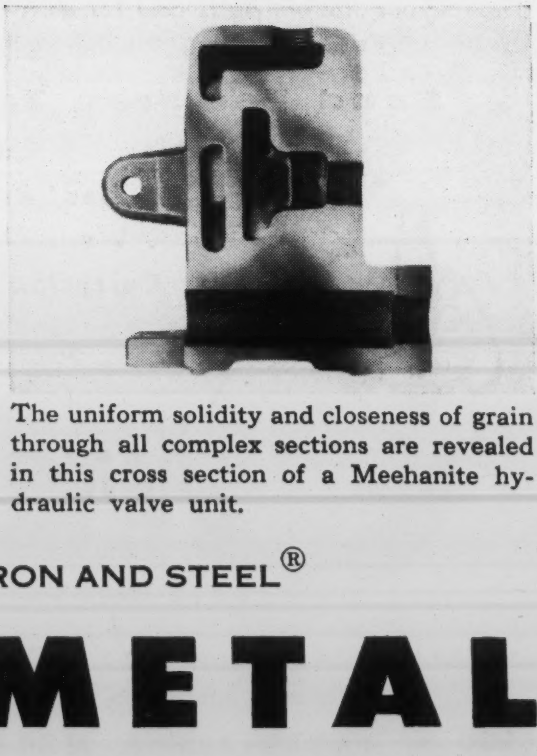
If you would like to know more about the advantages of Meehanite metal, write today for your free copy of bulletin #43 "Meehanite Castings for Pressure Tightness."



The uniform solidity and closeness of grain through all complex sections are revealed in this cross section of a Meehanite hydraulic valve unit.

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MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

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HEAT

CORROSION

WEAR

CASE HISTORY
#367

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Aeronautical Laboratory. Some of their conclusions:

1. Small cracks cause large decreases in static strength.
2. The static strength of specimens made of 7075 aluminum alloy is significantly more sensitive to the effects of cracks than is the static strength of similar specimens made of 2024 aluminum alloy.
3. On the basis of percentage of net area lost by fatigue cracking, wide specimens experience greater loss of strength than narrow specimens with similar configurations.
4. Specimens with final net area eccentric with respect to the loading have lower static strengths than similar specimens which are loaded along a line passing through the center of the remaining area.
5. There is little, if any, difference between static strengths of similar specimens made of sheet and extruded material of the same alloy.

Testing consisted of subjecting seven configurations of specimens made of 2024 and 7075 aluminum alloys in both rolled and extruded form to repeated axial loads until fatigue cracks of various lengths were formed. The specimens were then subjected to static tests to determine the residual static strength.

As outlined in *Technical Note* 3816 of the National Advisory Committee for Aeronautics, a secondary purpose of the investigation was to establish an analytical procedure for the determination of residual strength of specimens containing fatigue cracks, and thereby eliminate the need for much of the testing required to obtain the information experimentally. Briefly, the procedure is based on the assumption that the determination of residual static strength hinges on the determination of the maximum stress in the specimen. If it is assumed that failure occurs whenever the

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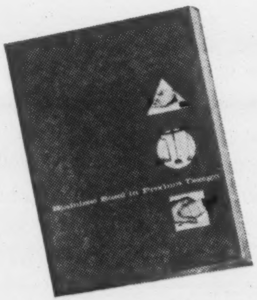
Such properties make stainless steel an ideal material for trailers, trains, planes, etc. They qualify it for myriad other applications, too. Chances are that *you* could use it when your product (or process equipment) requires superior strength, corrosion resistance, heat resistance, sanitary qualities, ease of fabrication, durability and attractiveness. ● We'd be pleased to discuss it with you—anytime you say or anywhere you'd like to meet. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*



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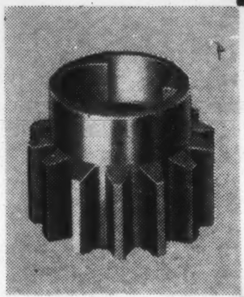

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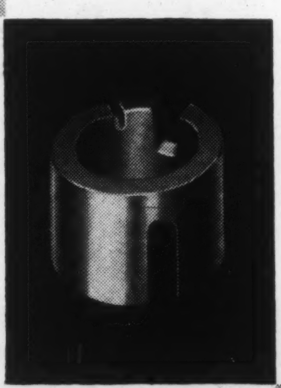

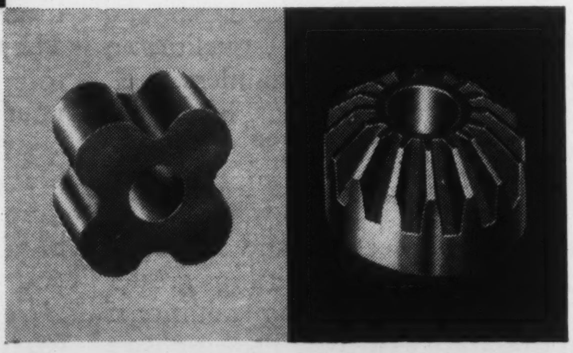

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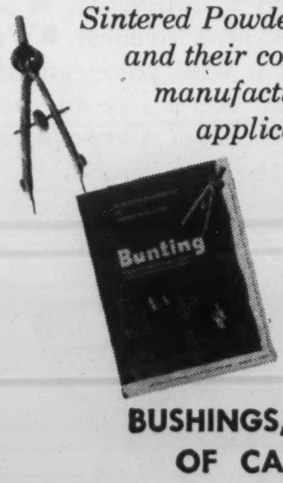

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maximum stress equals the ultimate tensile strength of the material, then the residual static strength can be predicted. The good correlation between experimental results and results calculated with the new method tends to justify the use of the analytical procedure, at least for the two aluminum alloys tested.

Phenolic Compound Is Noncorrosive

A new electrical grade phenolic molding compound has been developed by *Durez Plastics Div., Hooker Electrochemical Co.*, North Tonawanda, N. Y. Called Durez 18441, the molding material is ammonia free and is said to minimize corrosion of electrical contacts and metal inserts.

Applicable to compression or transfer molding methods, the wood flour-filled phenolic compound has a fast rate of cure. The molded material is said to have excellent insulation resistance and is characterized by good finish and low specific gravity.

PROPERTIES OF DUREZ 18441

Specific Gravity	1.36
Molding Shrinkage, in./in.	0.005
Water Absorption, %	1.0
Izod Impact, ft lb/in.[a]	0.29
Flexural Strength, psi[a]	9500
Tensile Strength, psi[a]	7500
Compressive Strength, psi[a]	25,000
Distortion Under Heat (264 psi), F	300
Mod of Elasticity in Tension, 10^6 psi[a]	1.3
Rockwell M Hardness	108
Dielectric Strength, v/mil[b]	
Short Time	425
Step-by-Step	300
Volume Resistivity, ohm-cm	1×10^{13}
Dissipation (power) Factor[b]	
60 cycles	0.05
1 kc	0.03
1 mc	0.03
Dielectric Constant[b]	
60 cycles	6.2
1 kc	5.9
1 mc	5.4

[a] Cond 48 hr at 122 F; tested at room temperature.

[b] Cond 48 hr at 50% R. H., 73 F.

For more information, Circle No. 598 ➤

PRICE$ AND SUPPLY

The Outlook

by Herman B. Director, *Consultant, Washington, D.C.*

Materials subsidies to continue

The present Administration's policies with respect to materials are likely to continue and will generally follow our State Department's lead in opposing tariff protection actions, as in the case of lead and zinc, and, more recently, fluorspar. As an alternative, the Administration has acted in favor of materials subsidies in the form of Government procurement programs.

Protection for domestic materials producers through increased tariffs or by way of the antidumping act has in the past met with little success. On the other hand, $30 million of additional funds have been requested, and will probably be approved, to purchase such materials as tungsten, asbestos, fluorspar, columbium, tantalum, and mica for Government account at prices far above world market prices. An additional $130 million has been requested in the new Budget for purchases running into 1958. The net effect of these actions is that these domestically produced materials go into Government stocks while consuming industries import virtually all of their requirements for these same materials.

No support for copper tubing manufacturers

As a result of the Government's subsidy programs, U. S. copper tubing producers will have a hard time gaining Administration support for protection from imports of copper tubing. The disparity between the price of foreign-produced copper and domestically produced copper can only make it increasingly difficult for tubing manufacturers to continue satisfactory operations.

Domestic copper producers are under continuing pressure to reduce prices. Just how far such reductions can go is difficult to measure, especially since the Government is being encouraged to buy up surplus copper if the price reaches 31¢ per lb. Entry of the Government into the market would put copper in the same category as lead and zinc, i.e., the Government would buy domestic copper and at the same time barter agricultural surplus for foreign copper in order to sustain the world price. However, it is doubtful whether the Government can act quickly enough to bolster the market.

Guaranteed floor price for nonferrous metals

Token offers of aluminum are being made to the Government under contracts calling for the Government to underwrite the aluminum expansion programs. The Government also provides a home for any surplus titanium which shows up in the marketplace. Our major nonferrous metals—copper, aluminum, lead, zinc, titanium, columbium, tantalum, (also materials such as fluorspar and mica)—are, therefore, guaranteed a floor price. This introduces a rigidity into the market which consuming industries cannot alter. In the face of increased supplies of virtually all of these materials, we would normally expect reductions in price. However, the support programs will make it impossible for the benefits of increased supplies to be passed on to the consumers.

Industrial diamond supplies tight

Industry is currently feeling a bad pinch in the supply of industrial diamonds for grinding wheel and other applications. The Diamond Syndicate, from which virtually all diamonds are imported into the U.S., has reduced supplies by amounts ranging from 8 to 40%. In recognition of this reduction of supply, the Government has ceased all purchases for its own stocks and has suspended barter transactions.

The shortage in the supply of diamonds is especially important in view of the rapid strides being made by cemented tungsten carbide tools, which are sharpened by diamond grinding. In fact, high speed tool steels are losing out to cemented carbides; one leading producer of both materials indicates that as much as 50% of his business has shifted from high speed steels to cemented carbides. Estimates for

The Outlook—continued

1957 show another sizable increase of as much as 10% in the growth of tungsten carbide tools.

An encouraging note, insofar as diamond supply is concerned, comes from General Electric Co. which says that progress in manufactured diamonds is ahead of schedule and commercial quantities will be available sooner than had been expected.

New Year forecasts too optimistic

The first wave of New Year forecasts is happily now over. Virtually all materials suppliers have forecast increased sales of their materials. These forecasts have generally been based upon increased usage in automobiles of most materials, including aluminum for trim and die castings, zinc for die castings, copper for wire and other applications, cotton for padding and upholstery, Mylar and vinyls for upholstery and protective coatings, and other plastics for trim and functional parts. We believe, that these early forecasts are perhaps too optimistic. For example, estimates of 50 lb of aluminum per car have now been shaded by more precise market research down to 38.1 lb per car for the 1957 models, as compared with about 35 lb for the 1956 models. Enthusiastic estimates of this type may lead to unusually abundant supplies of some of these materials.

Steel demand will force revision of product mix

Demand for steel continues to be high in spite of producers' statements that demand for cold rolled sheets for automobiles and appliances is declining. There is still enough demand for other products to sustain steel production at a high rate. A change in the demand pattern might cause some of the mills to revise their product mix and switch more ingot tonnage to items in stronger demand. As sheet and strip rolling facilities become more readily available, there could be an increase in the use of these facilities for rolling light plate.

Two days after the Administration turned down the steel industry's request for rapid tax amortization covering its $2.3 billion expansion program, the Joint Congressional Committee on Internal Revenue Tariff issued a statement which actually leaves the door open to further tax amortization with respect to steel plate and structural shapes. In the statement, the Committee recognizes the fact that there will be pressures for subsidies from new companies which are not producing specific defense items, but which, nevertheless, can be easily converted if necessary. For example, a plant producing heavy steel plate for mining equipment or for ocean vessels could be turned to war production in an emergency faster than, say, some sheet mill that the Government presently plans to convert. As a result, "there will be a more or less steady stream of certifications of this sort."

Butadiene may be source of new materials

Butadiene is expected to become a rival of ethylene in the near future as a starting material for plastics and petrochemicals. At present, butadiene is used primarily in synthetic rubber production; ethylene, of course, has wide application in the plastics and chemicals field.

The butadiene program should get off the ground later in the year when new facilities are expected to go into operation. It is believed that butadiene could be used more efficiently and economically than ethylene. At present, neither butadiene nor ethylene is in surplus supply.

Titanium promoted in Senate report

The Senate Committee on Interior and Insular Affairs has issued a special report on titanium. This report calls attention to the growth of the industry and criticizes the Administration for halting its expansion program. The testimony, as reported, indicates that both supplies and technology are improving and that supply is more than adequate to meet current demand. The Committee, however, urges further expansion of titanium production in all forms. This Committee has spent more time on titanium than on any other material.

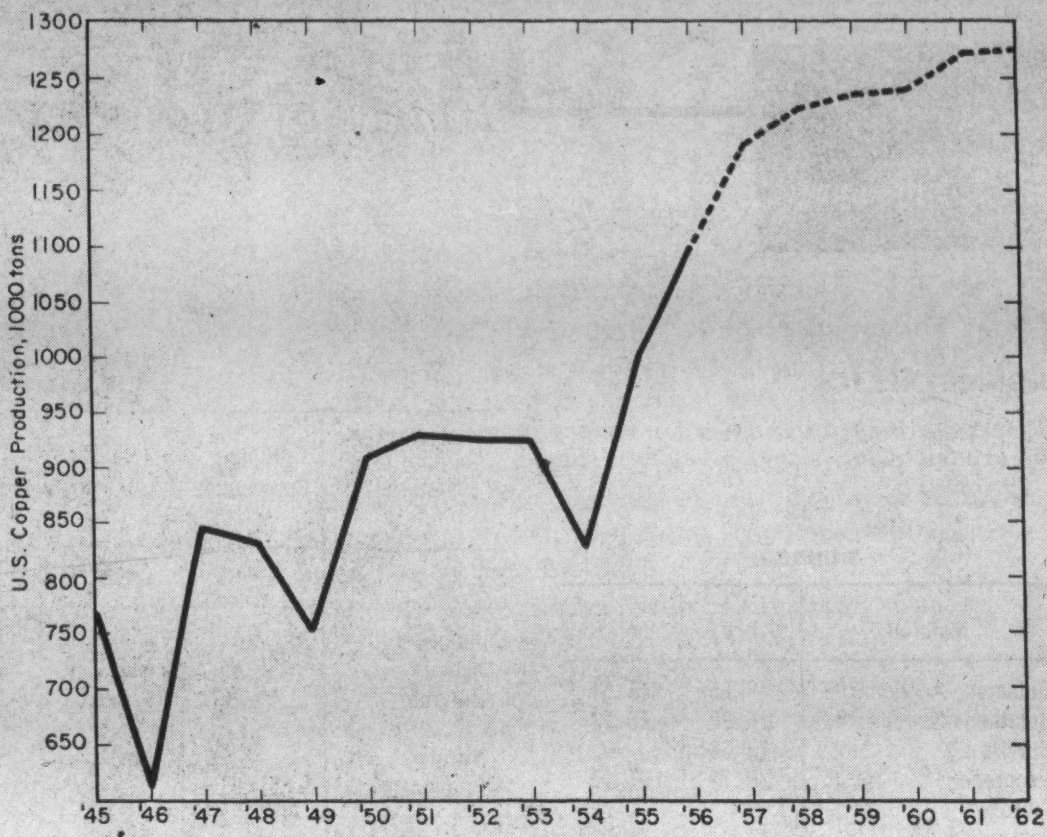
Platinum prices reduced

Platinum prices have been lowered considerably. Nevertheless, transactions on the recently opened New York Exchange do not seem to be very active. It is reported that Russian platinum, which we estimate to be in plentiful supply, has been entering world markets. If this is true, it could be a forerunner of similar U.S.S.R. activities in less expensive materials, such as manganese and chromium.

U. S. industry has demonstrated an ability to utilize palladium at $23 per oz, as compared with platinum at about $100 per oz. This, coupled with reported dumping by the U.S.S.R., could be responsible for the drop in platinum prices. It is not inconceivable that the price of platinum will drop still further.

Fiberglass threatens asbestos

Recent developments in fiberglass technology may lead to increased supplies at prices competitive with that of imported asbestos. There are many applications for which asbestos, rather than fiberglass, has been specified only because of price considerations. New developments by domestic fiberglass producers are destined to overcome this price differential and relieve the continued pressure for imported asbestos for thermal insulation.



***U.S. copper production** from 1945, including estimates to 1962.*

Copper:

Abundant Supply at Lower Prices

■ The possibility of a serious copper shortage within the next five years is remote. According to the Copper and Brass Research Assn., at least three favorable factors can probably be counted on: 1) greatly increased capacity at new mine facilities scheduled for completion by 1962; 2) continued and extensive exploration for new ore bodies; and 3) steady output from domestic sources as a result of a three year labor agreement concluded at all major U. S. mines.

Assuming no major depressions or disastrous wars, and no serious work stoppages from any cause, the prospects are that free world mine capacity should reach almost 4 million tons by 1962. Compared with an actual production of just over 3 million tons in 1955, this would be an increase of 31% over current capacity.

On the other hand, consumption is lagging behind production. Last year saw at least two major price reductions as a result of oversupply. Indications for 1957 are that the unbalanced supply-demand situation will continue, even to the point of further reductions in copper prices below the 32¢ a lb level recently announced. The long term outlook, however, according to CABRA, points to extensions in the use of copper to balance out the picture.

For example, per capita consumption of copper in the free world (excluding the United States) in 1955 was 2.9 lb; U.S. per capita consumption was 18 lb. The free world population is increasing at a rate of more than 35 million every year and, depending upon the ability of underdeveloped nations to mechanize their industries, world consumption will probably rise. In the meantime new applications for copper continue to be found.

One of the most recent innovations in building construction is use of a copper alloy "curtain wall" to enclose a skyscraper. In the first transatlantic telephone cable, which went into operation last year, copper was a vital element. In atomics, copper is indispensable for particle accelerators—cyclotrons, betatrons, generators, etc. Copper is used extensively in automation equipment. All of these relatively new industries will undoubtedly expand and increase their use of copper.

(Prices of Materials on p 228)

Where Copper Is Used

(Percent of Total)

Electric lines (light, power, communications)	19
Electrical equipment (incl communications)	18
Construction (building materials, pipe, tube, sheet)	14
Motor vehicles	8
General components	6
Consumer durable goods	3
Electronics	2
General industrial equipment	2
Railroad equipment	2
Scientific, technical equipment	2
Engines, turbines	1
Metalworking equipment	1
Military (conjectural)	17
Undistributed	2
Miscellaneous industries	3

Prices of Materials

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	.44-.54
Butadiene-Styrene	.16-.30	.26-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	.47-1	.70-.92
Natural	.37	—

[a] Less than carload quantities.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd, 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	1.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a] Price includes binder or finish.
[b] Price varies with binder.
[c] 0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.40	.17-.34
Polyester	—	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a] 60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
PTFCE	7-12	15-23	18-22		20-22.50	
PTFE	4.50-7.45	14.30-11	13		13	
Nylon	1.35-2.30	—	3		3	
Polyethylene	.37-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.27-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.25-.27
Ingot (99-99.9%)	.27-.29
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.29-.32
Sheet (1100, 3003; 3-.03 in.)[a]	.40-.45
Plate (1100, 3003, 5050, 3004, 5052)[a]	.40-.43

[a] Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.50	.53	.55
Seamless Tubing	.53	.56	.57
Rod (not f.c.)	.50	.53	.55
Wire	.51	.54	.55

COPPER

Ingot (elec)	.36
Sheet, Strip (hot rolled)	.58
Seamless Tubing	.58
Rod, Drawn	.55
Rod, Free Cutting	.64
Wire	
Round	.41
Square, Rectangular	.45
Magnet	.49

LEAD

Common Grade	.16

MAGNESIUM

Pig (98.8%)	.36
Ingot (98.8%)	.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a] Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	.75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a] Delivered price.

TIN

Primary[a]	1.09

[a] Delivered price.

(Prices continued on p. 230)

OVER-DESIGNING ?

If you are designing bronze parts for mass production, there is a good chance that you are specifying a more costly alloy than you need.

ASARCO's patented continuous-casting process produces alloys according to SAE, ASTM and Government specifications. But their performance is entirely unlike that of similar alloys cast in sand or permanent molds. Relatively low-cost alloys cast by the ASARCO process perform like more expensive alloys cast by other methods.

For example, compare Continuous-Cast SAE 660 (ASARCON 773) with more expensive sand-cast alloys:

	Typical Yield Strength	Typical Impact Strength	Brinell Hardness
ASARCON 773	27,000 psi	12.5 ft.-lbs.	72
Sand-Cast SAE 62	20,000 psi	8.7 ft.-lbs.	65
Sand-Cast SAE 64	17,000 psi	8.2 ft.-lbs.	62

Unless you've checked to see whether the unique ASARCO bronzes can give you what you need, there's a possibility that you're over-designing. You may even be able to replace aluminum and manganese bronzes with low-cost ASARCON Continuous-Cast bronzes under certain conditions. Over-designing can be expensive in mass production, even if you are spending only a penny or two extra per pound of bronze.

ASARCON 773 (SAE 660) is readily available from stock in a wide range of sizes. An added bonus is the fact that ASARCON 773 is exceptionally free-machining. Rods, tubes, and numerous "extruded" shapes up to 9 inches in diameter are cast to order by ASARCO in more than 20 alloys.

We'll be happy to send you a free booklet describing the process and the product.

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Underneath the exteriors of each of "tomorrow's" automobiles, you'll find a quarter of a ton of gray iron castings. Progressive designers and purchasing agents in other industries are also taking a new look at modern gray iron utilizing its characteristics to keep pace with modern designs. These keen buyers realize that it is often more costly to duplicate the engineering properties of gray iron with competitive materials. Consider gray iron castings first in the design and purchase of parts for modern products.

Buy from reliable foundries displaying the GIFS symbol! Write for Buyers' Guide and Directory of members.

With modern gray iron castings you have a choice of over 30 types of metallic and non-metallic coatings.

it's time to design with

GRAY IRON CASTINGS

GRAY IRON FOUNDERS' SOCIETY, INC.
National City-East 6th Bldg. • Cleveland 14, Ohio

For more information, turn to Reader Service Card, Circle No. 426

PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	2.50-2.75
Bars, Rod	7.10-7.35
Plate	9.25-11.25
Sheet, Strip	11.40-12.10
Wire	8.50-9.00

ZINC

Primary[a]	.13-.14[c]
Die Casting Alloys[b]	.18-.19[c]
Sheet	.24
Ribbon	.22

[a] Prime Western—Special High Grade. [b] Alloys 2, 3, 5. [c] Delivered price.

METAL POWDERS

Aluminum [a,b]	.36
Brass[a]	.37-.47
Copper (elec or red.)[a]	.50
Columbium	120
Molybdenum (98%)	3.80-4.10
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	4.20-5[c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a] Price for —100 mesh. [c] Delivered price.
[b] Freight allowed.

OTHER NONFERROUS METALS

Cadmium (bars)	1.70
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.33[a]
Palladium	$23-24/troy oz
Platinum	$98-101/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	3.45
Zirconium (sheet, strip, bar)	27-35

[a] Delivered price.

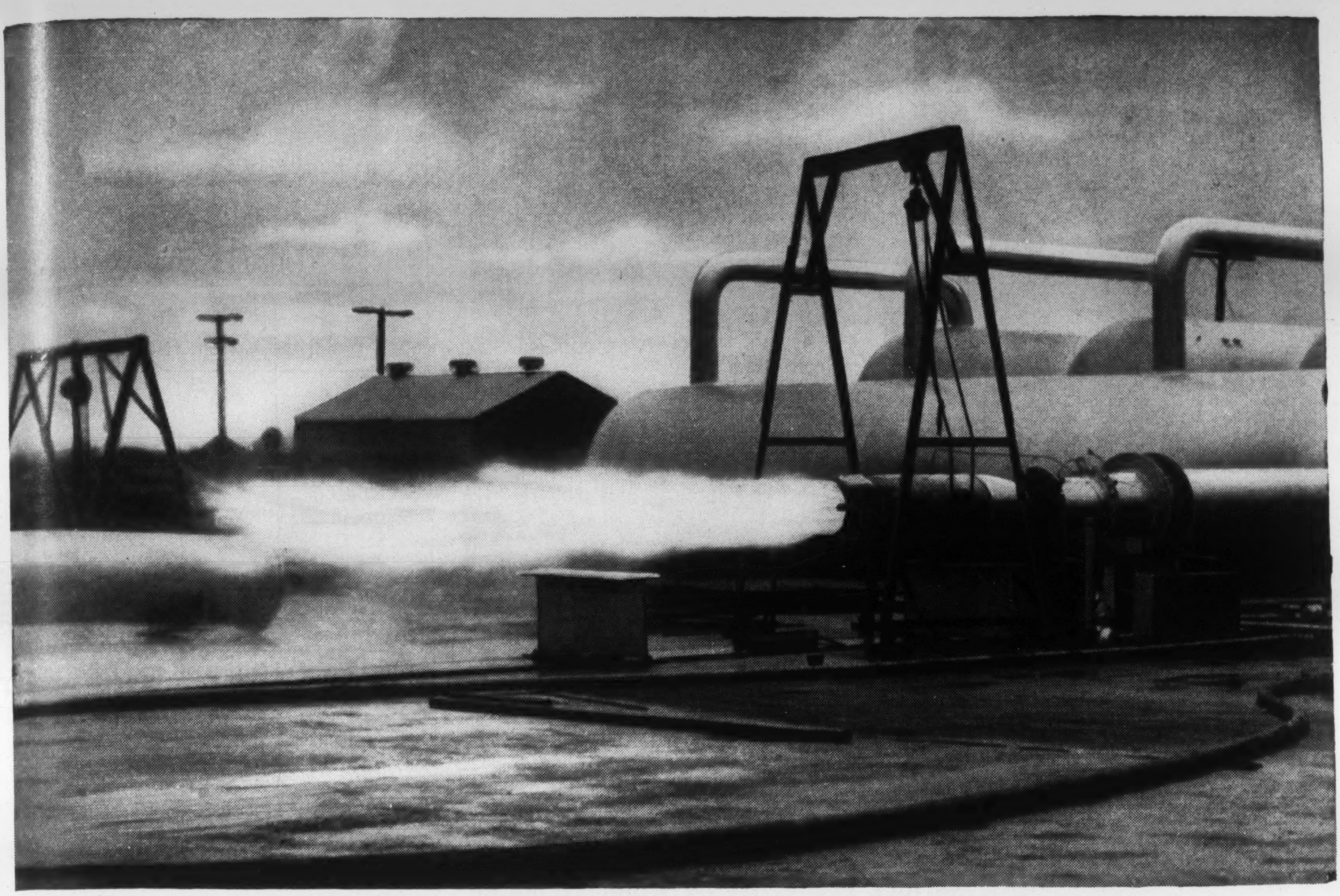
IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	74
Billets, Blooms, Slabs	
Carbon, Re-rolling	74
Carbon, Forging	92
Alloy, Forging	107
Seamless Tube Rounds	112
Wire Rods	$5.85/cwt

(Prices continued on p 232)



Ramjet tailpipes withstand severe abuse. (*Photo courtesy Marquardt Aircraft Company*)

MULTIMET Alloy Controls the Blast of Ramjet Engines

Tailpipes used to direct the searing blast of power in today's ramjet engines must withstand temperatures in excess of 2000 deg. F, plus severe vibration. High-speed ramjets operate in the neighborhood of 1500 mph. At these high speeds, vibration is almost as serious a threat to tailpipe life as heat. Because of its strength at high temperatures, MULTIMET alloy has given good service in tailpipes that vibrate as much as three inches.

Ramjet tailpipes are made of MULTIMET alloy sheet that is only 0.051 to 0.078 in. thick. The combined high-temperature strength and oxidation resistance of MULTIMET alloy permits the use of lightweight tailpipes with good heat-transfer properties.

MULTIMET alloy is one of many HAYNES alloys capable of extending the life of parts used at high temperatures. For literature describing the properties of HAYNES high-temperature alloys, get in touch with the nearest Haynes Stellite Company Office.

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"Haynes" and "Multimet" are registered trade-marks of Union Carbide and Carbon Corporation.

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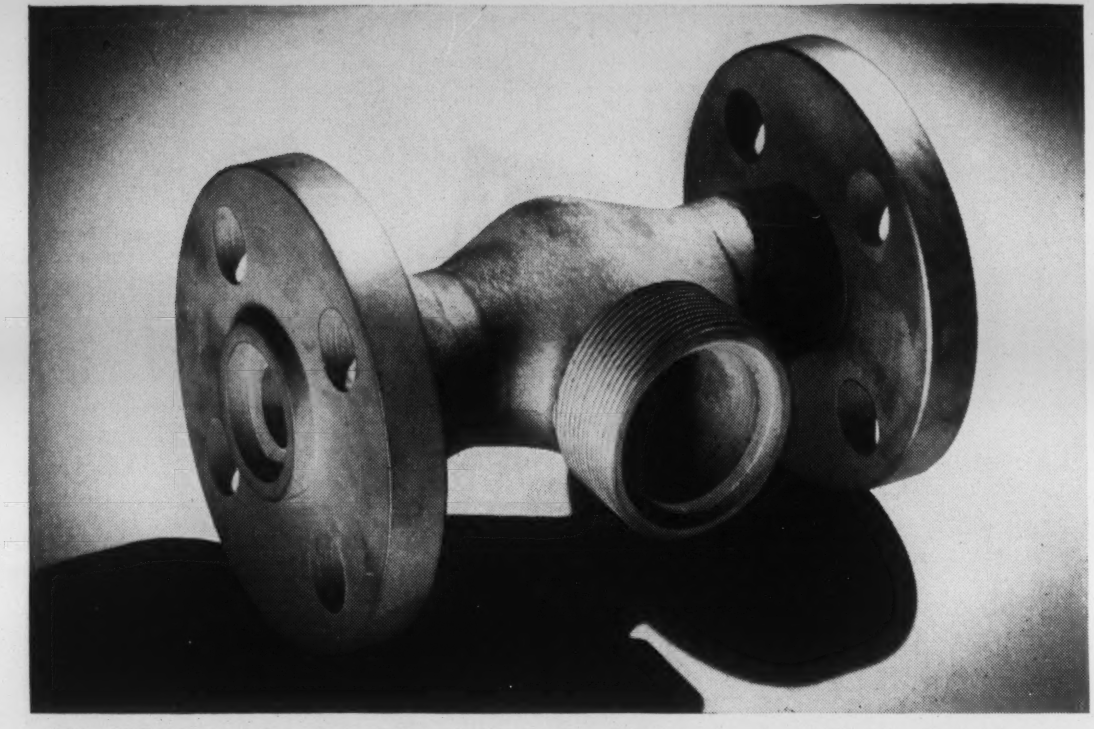
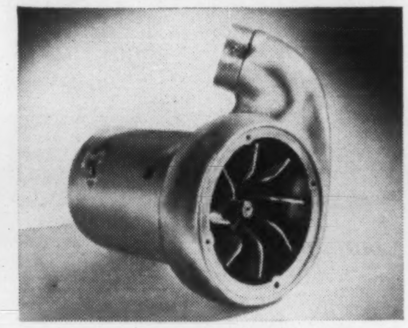
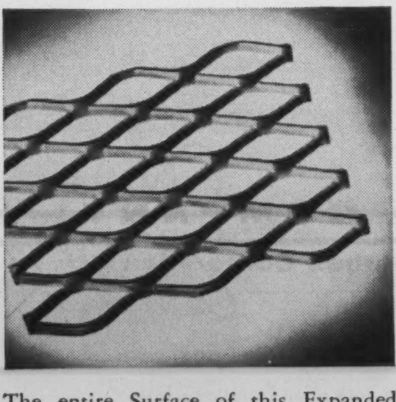


This ASC Processed Forged Steel Valve produces the equivalent of a forged Stainless Steel valve for about 50% of the cost. Note that all surfaces including drilled holes, flanges and threads are protected.



Stainless Alloy Surface applied to blower impeller provides corrosion protection whether blower is moving air, steam or corrosive fumes.

Nuts and Bolts — Stainless Alloy Surfaced — have better strength than Stainless Steel and have corrosion resistance equal to 430 Stainless. There is no growth on male or female threads — fit is not disturbed.



The entire Surface of this Expanded Metal Chemical Platform is completely protected by Stainless Alloy Surface at low cost against chemical corrosion.

Corrosion Resistance

Ordinary Steels Given 430 Stainless Surface Properties by Atom Exchange

A new process — ASC Metal Diffusion — can vastly increase the corrosion resistance of steels having a carbon content of 1008 to 1053. By the interchange of iron and chromium atoms, a *Stainless Alloy Surface* is created — the equivalent of 430 stainless — that becomes an integral part of the parent metal. Not a plating, coating or cladding, it will not craze, crack, peel or chip. Finished or unfinished products can be processed, and completed work can be formed, welded, brazed, soldered, or polished by methods in general use. Little or no dimensional change occurs as a result of the Process.

In addition, the Process can give low and medium carbon steels heat protection up to 2600°F., and medium and high carbon steels surface hardness of RC 70-72. ASC Metal Diffusion greatly widens application engineering in iron, steel and ferrous alloys. Write today for further information, consultation, or product demonstration.

ALLOY SURFACES COMPANY

103 South Justison St., Wilmington 1, Del.

For more information, turn to Reader Service Card, Circle No. 531

PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	4.85	7.25	6.85
Sheet, H.R.	4.67	6.90	—
Sheet, C.R.	5.75	8.52	—
Strip, H.R.	4.67	6.95	7.75
Strip, C.R.	6.85	10	14.55
Bar, H.R.	5.07	7.42	6.12
Bar, C.F.	6.85	—	8.30

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate[b]	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.36-.40	.41-.46	.45-.49	.50-.56
321[a]	.45	.53	.58	.63
347[a]	.54	.62	.67	.76
Martensitic				
410[a]	.27	.33	.34	.39
416	.28	.33	.35	.47
403	.31	.36	.39	.47
420, 440	.33	.40	.44	.60
Ferritic				
405, 430, 430F[a]	.28-.29	.33-.34	.35-.36	.39-.50
442	.32	.38	.40	.54
431	.36	.42	.44	.54
446	.38	.45	.46	.67
High Mn				
202[a]	.35	.41	.43	.47
Extra-Low C				
304L	.47	.53	.56	.61
316L	.64	.74	.78	.82
Precip Hard.				
17-7PH	.55	.65	.72	.77-.82

[a] Ingot prices approx 60% of forging billet price.

METAL POWDERS ($/lb)[a]

Sponge Iron	.09-.10
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.34
Stainless Steel	
302	1.05
316	1.40

[a] Price for —100 mesh.

IRON ($/gross ton)

Pig	62.50-63.50

(Prices continued on p 237)

PRICE$ AND SUPPLY

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	9.70-9.95
Elec (0.25-0.75 lb)	8.40-9.15
Black Plate	7.50-7.60

FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.50
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.50
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.00
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.50
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.50
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.50
Vinyl	1.0	2.0	2.50
Acrylic	1.0	2.0	2.75

[a] Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.

[b] Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

What's Happening in Prices and Supply

Steel—The steelmaking capacity of the United States has increased to 133,459,150 net tons, the highest level ever attained, according to the American Iron and Steel Institute. This is an increase of more than 5 million tons over 1955 and represents more than

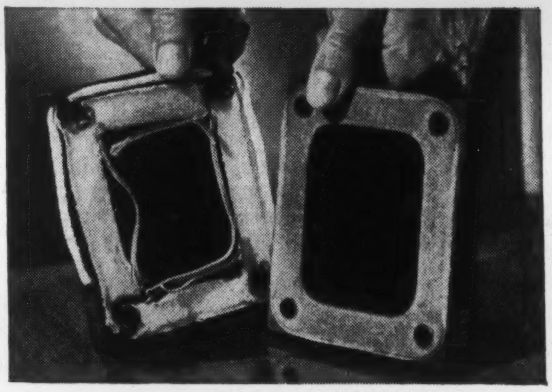
◄ For more information, Circle No. 600

IS NOT ATTACKED BY FUMING NITRIC ACID

Reinforced Teflon (DUROID 5600) showed no sign of attack after 48-hour immersion in Type IIIA fuming nitric acid at 80°F.

DOES NOT COLD FLOW UNDER PRESSURE

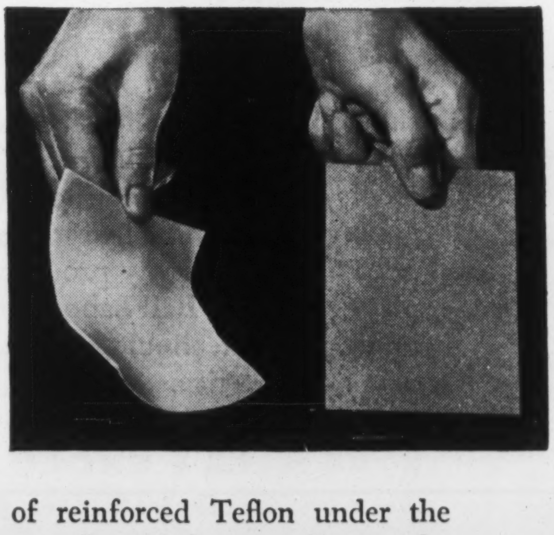
Reinforced Teflon (DUROID 5600) at right resisted torque and flange pressure that caused extrusion of Teflon.



REINFORCED TEFLON*
(DUROID 5600)
INDICATED FOR CRITICAL GASKET USE

GREATER RESISTANCE TO HEAT DISTORTION

Teflon (left) distorted badly when subjected to 720°F. and then cooled. Reinforced Teflon (DUROID 5600) retained flatness.



Rogers makes several grades of reinforced Teflon under the designation DUROID 5600 series. One of these grades may be just the material you need for a critical gasket application. Please write Dept. M for technical data.

*Registered trademark of DuPont Company for its tetrafluoroethylene resin.

ROGERS CORPORATION ROGERS CONNECTICUT

DUROIDS • SHOE MATERIALS • ELECTRICAL INSULATION • PLASTICS • RUBBER • FABRICATING • DEVELOPMENT

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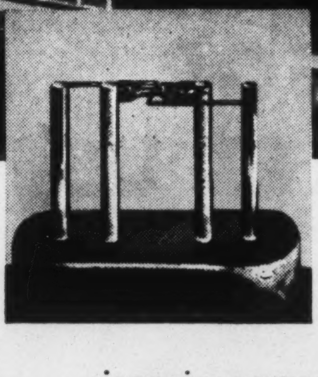
How
BELL TELEPHONE
LABORATORIES
assure precision in
sub-miniature assemblies
with 3-D
MICRO-VISION



This transistor is enlarged 6 times. You can't see much detail in its actual size, like this . . . That's why Bausch & Lomb Stereomicroscopes are built right into Bell Laboratories' ingenious experimental machine, "Mr. Meticulous," which automatically assembles hair-thin elements in steps involving movements of 1/20,000 of an inch! Without visual fatigue, technicians get vividly magnified views of these tiny parts and intricate operations. We're mighty proud of the part B&L Stereomicroscopes play in helping Bell Laboratories achieve miracles in electronic technology to improve telephone service.

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40% of the world's capacity.

Benjamin Fairless, AISI president, says that the national steelmaking capacity "has been increased every year for ten years in succession and is 45% higher than at the end of World War II."

Indications of higher prices to come continue to pile up. John F. Smith, Jr., Inland Steel Co. vice president, recently stated that "steel prices must be increased, beyond the increment for current cost increases, so that earnings based on invested capital will put the steel companies in a position to successfully compete in the financial markets for their new capital requirements."

Platinum—The price of refined platinum has been reduced $5 an ounce for large quantities and $4 an ounce for small lots, making the new range $98 to $101. The reduction is said to be the result of Russian offerings of the metal.

Uranium — The world's first production by private industry of enriched uranium for use in atomic power plants is under way at the Mallinckrodt Chemical Works plant in Hematite, Mo. The material, uranium dioxide enriched in the isotope U-235, is manufactured to customer specification and shipped to plants where it is fabricated into shapes useful for atomic reactor cores.

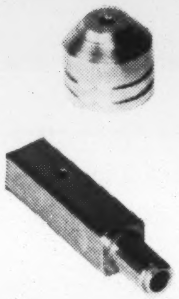
Cemented carbides — Between 7% and 9% more cemented carbides will be consumed in 1957, according to K. R. Beardslee, general manager of General Electric Co.'s Metallurgical Products Dept. Mr. Beardslee based this prediction on the fact that "a recent survey indicates consumption of cemented carbide metals has been steadily increasing since 1950 at a 5-8% per year rate."

Manganese — A new company, U. S. Manganese Corp., will produce manganese from domestic ores. At present the U. S. uses about 2 million tons of manganese yearly, 95% of which is imported. It is hoped that the new company

INDUSTRIAL ENGINEER AT ALCO VALVE CO. REPORTS . . .

"We stepped up parts production 700% by deburring and polishing with ALMCO EQUIPMENT"

MR. HAROLD KRAUSHAAR, Industrial Engineer at Alco Valve Co., St. Louis, shows solenoid valve parts on which Almco barrel finishing equipment recorded vital production increases.



KEEPING PACE with over-all stepped-up plant production requirements was not easy at Alco Valve when it came to finishing of piston and plunger valve parts.

These stainless steel screw machine parts were being deburred and polished by hand at the rate of slightly over 200 per hour.

It threatened to become a bottleneck, and in addition, stricter finishing specifications were calling for 25 micro-inch on both plungers and pistons, further increasing man hours.

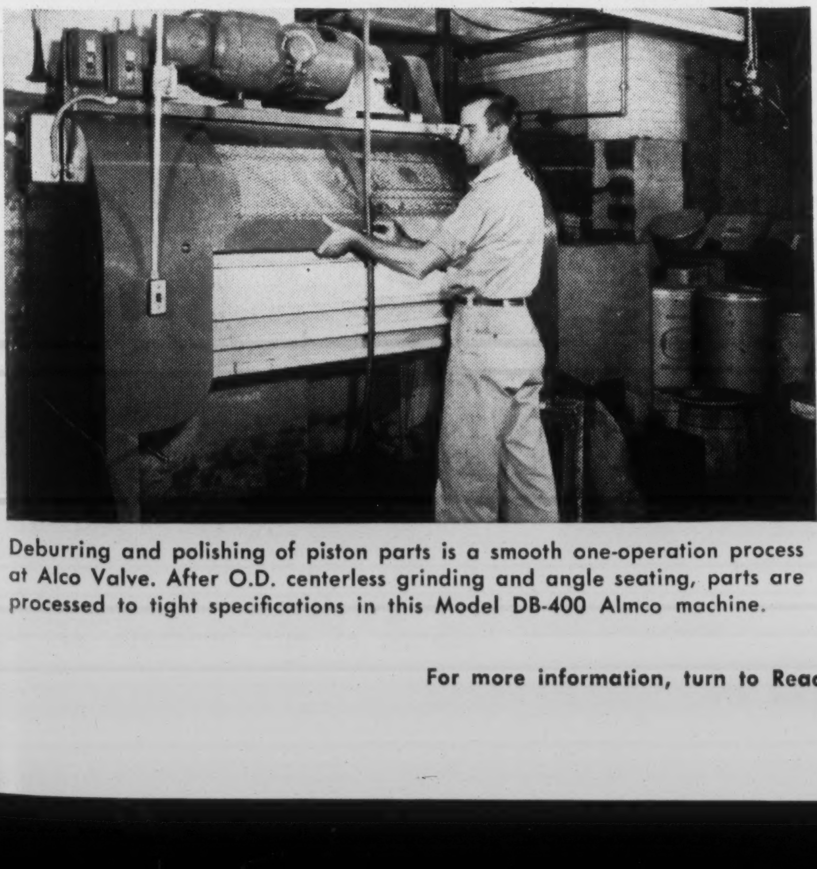
FINISHING PRODUCTION SOARED — After detailed lab analysis and testing procedures on typical parts by Almco engineers, an Almco Model DB-400 barrel finishing machine was installed. Production rate on deburring and polishing rose from 200 per hour to over 1400 per hour — a direct increase of 700%! Plant production schedules were met without difficulty.

REJECTS PRACTICALLY ELIMINATED — The Almco method of deburring and finishing not only mastered the stricter micro-inch requirements, but cut rejects to a bare minimum. Since hand operations were completely eliminated, costly variables were no longer present.

MODERN TECHNIQUES IN BARREL FINISHING — It will pay you to investigate what Almco barrel finishing can do for your company. Almco's technician-staffed laboratories can help you by examining your product parts, running them through detailed sample processing to determine what combination of machine, compound, media, cycle, etc., will produce the results you want, at lowest possible cost.

All you have to do to get a complete report with absolutely no obligation is to write Almco, asking an engineer to call and arrange it. Or, send sample parts and specifications on results desired direct to Almco's main laboratory at Albert Lea, Minnesota.

You will be interested to know that Almco case history reports now cover a tremendously broad variety of parts, metals, and finishes. Get information on your requirements now!



Deburring and polishing of piston parts is a smooth one-operation process at Alco Valve. After O.D. centerless grinding and angle seating, parts are processed to tight specifications in this Model DB-400 Almco machine.

SEND FOR THIS NEW BARREL FINISHING HANDBOOK

Complete description of the most advanced modern processes. 52 pages of facts, photos, data and cost comparison charts. Write for your personal copy today.

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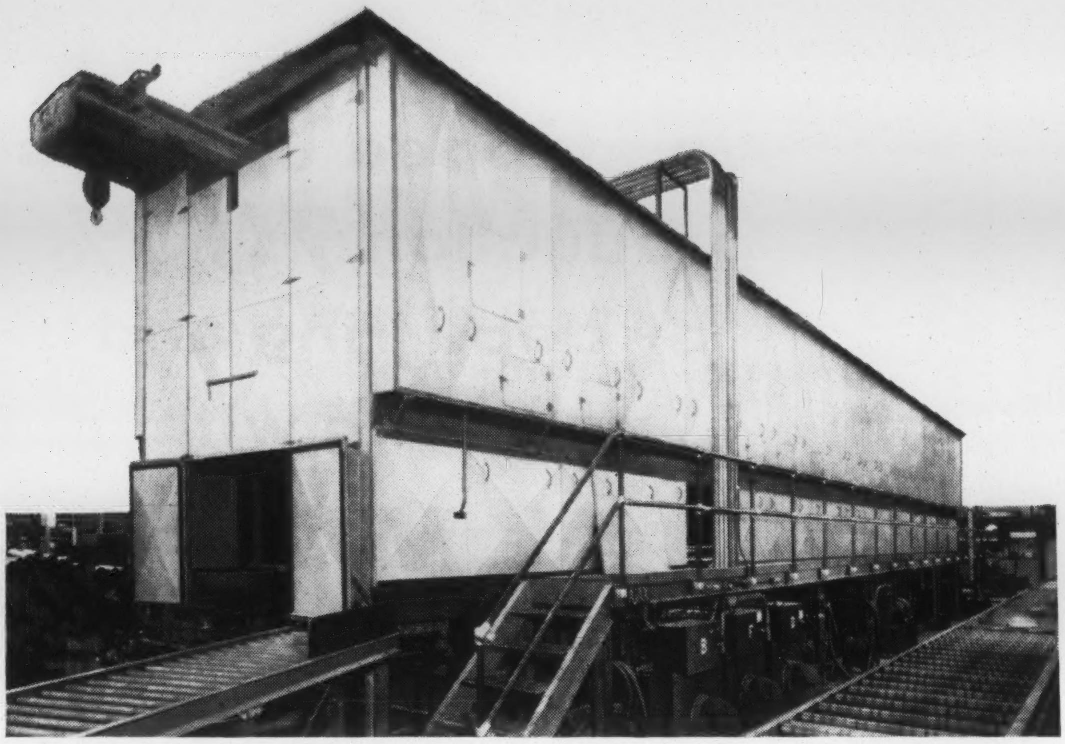

HEAT TREATING MECHANIZATION

IS A FAMILIAR STORY TO AJAX!

■ In hundreds of applications, complete heat treating cycles are handled automatically by conveyorized salt bath installations engineered from beginning to end by Ajax.

From small parts to big ones; whether difficult shapes or selective heating requirements, the work is done faster . . . at less cost . . . in less floor space . . . with exceptionally uniform results.

From single furnaces to elaborate combinations, each operation is automatically operated and controlled, and the human element eliminated.

Exceptionally broad experience with merry-go-round, jackrabbit, screw conveyor, rotary basket, swing, elevator, push-pull and other heat treating mechanisms gives Ajax a head start on solving your mechanization problem the minute you bring it to us.

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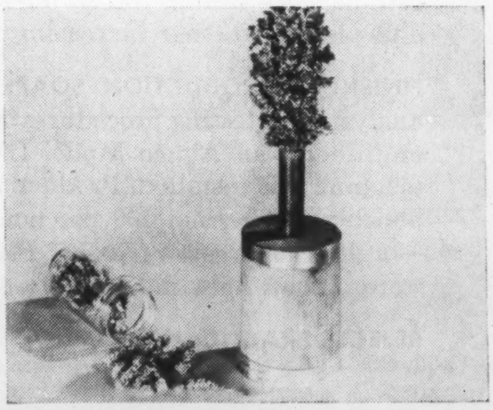
will eventually produce enough to make the U. S. independent of foreign sources in case of war.

Rubber — Non-tire, industrial rubber consumers should use about 750,000 tons of rubber in 1957, or 38% of the country's total rubber consumption, according to Thomas Robins, Jr., president of Hewitt-Robins, Inc. Mr. Robins feels that production facilities have been expanded to a point where supplies of most products are approximately in balance with demand.

Plywood—Prices of fir plywood, which fell from $95 per 1000 sq. ft. in 1948 to $67 in 1956, will probably be established at $72 in 1957. The "big four" plywood producers—U. S. Plywood Corp., Simpson Logging Co., Long-Bell Div. of International Paper Co. and Georgia - Pacific Plywood Corp., as well as several smaller companies, have issued new price lists at $72.

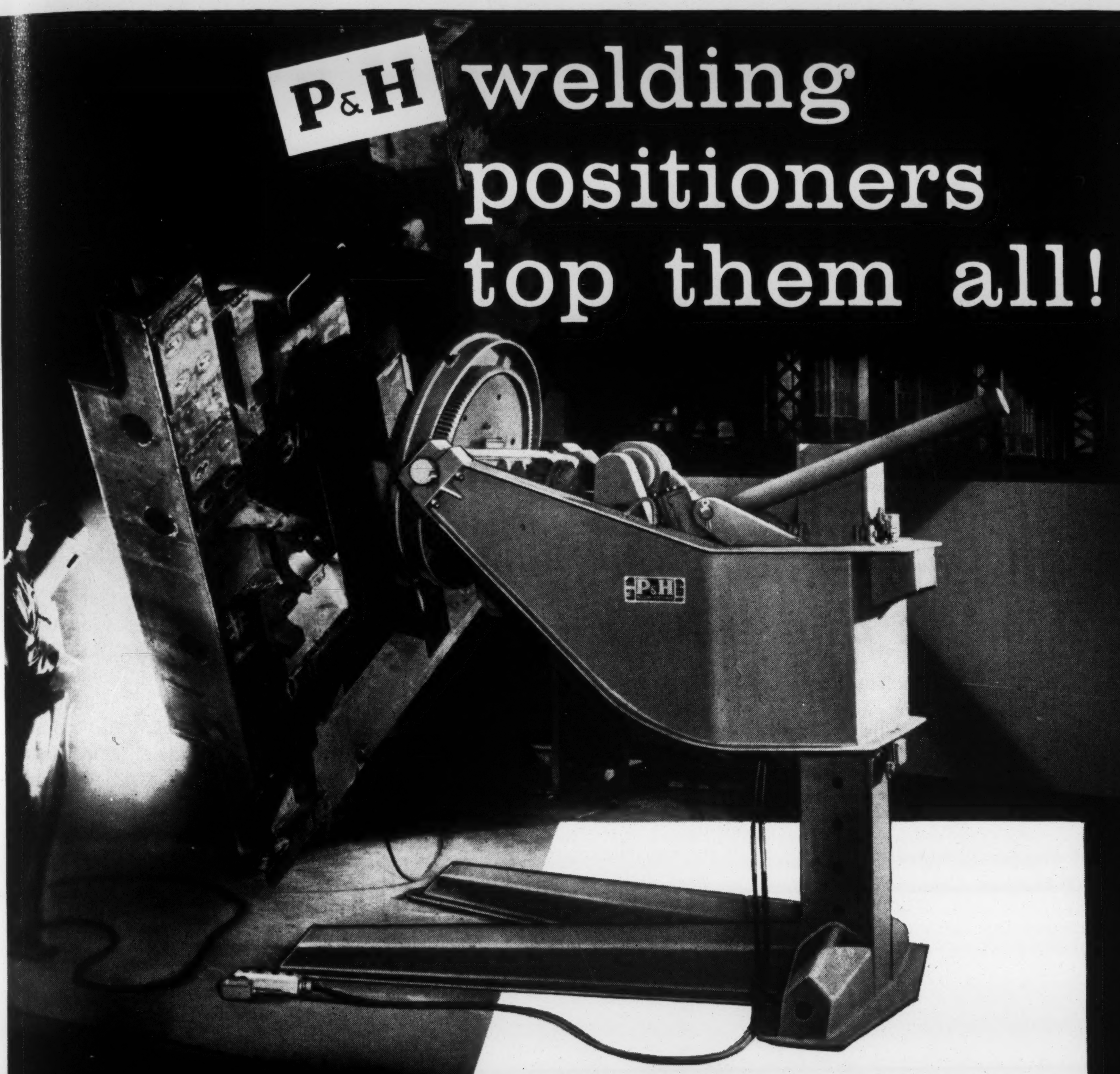


***New refining process** yields crystals of pure titanium.*

Titanium Supply Up; New Refining Process

Since its inception six years ago the titanium industry has doubled and redoubled production at a phenomenal rate. Production of finished mill shapes in 1956 totaled 10,600,000 lb, about 25% higher than first-of-the-year estimates. In 1957, the industry expects to produce about 23 million pounds of mill products, an in-

50% greater elevation means larger weldments...faster welds



P&H welding positioners top them all!

Height comparison chart for model WP-3 P&H Welding Positioner

Mfr.	Minimum	Maximum	Range
P&H	46¼″	82¼″	36″
"A"	34½″	54½″	20″
"B"	42″	66″	24″
"C"	40″	55″	15″

The chart on the left clearly shows how a typical P&H Welding Positioner has a 50% greater elevation—can turn larger weldments and lift them almost 1½ feet higher than competitive makes.

Welding is easier, faster, with a P&H Positioner. Table tilt is clear through 135° — without legs or posts to interfere with rotation.

Capacities range from 500 to 100,000 lbs. Send today for booklet "What you should know about Welding Positioners." Address: Dept. 311G, Welding Division, Harnischfeger Corporation, Milwaukee 46, Wisconsin.

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P&H WELDERS · ELECTRODES · POSITIONERS
Milwaukee 46, Wisconsin

For more information, turn to Reader Service Card, Circle No. 572

crease over 1956 of about 135%. Sponge production, about 29 million pounds in 1956, is expected to increase to about 50-56 million pounds.

The price trend was downward throughout all of 1956. Titanium Metals Corp. of America reduced mill product prices by 12%. Du Pont reduced sponge prices from $3.45 to $2.75 per lb.

Expansion

Sizable expansion plans were announced by TMCA and Du Pont during 1956. In addition: Republic Steel Corp. and Cramet, Inc. joined forces to produce titanium; Kennecott Copper Corp. and Allied Chemical Corp. formed a joint subsidiary to produce titanium; National Distillers Products Corp. announced plans for a 5000-ton-per-year sponge plant.

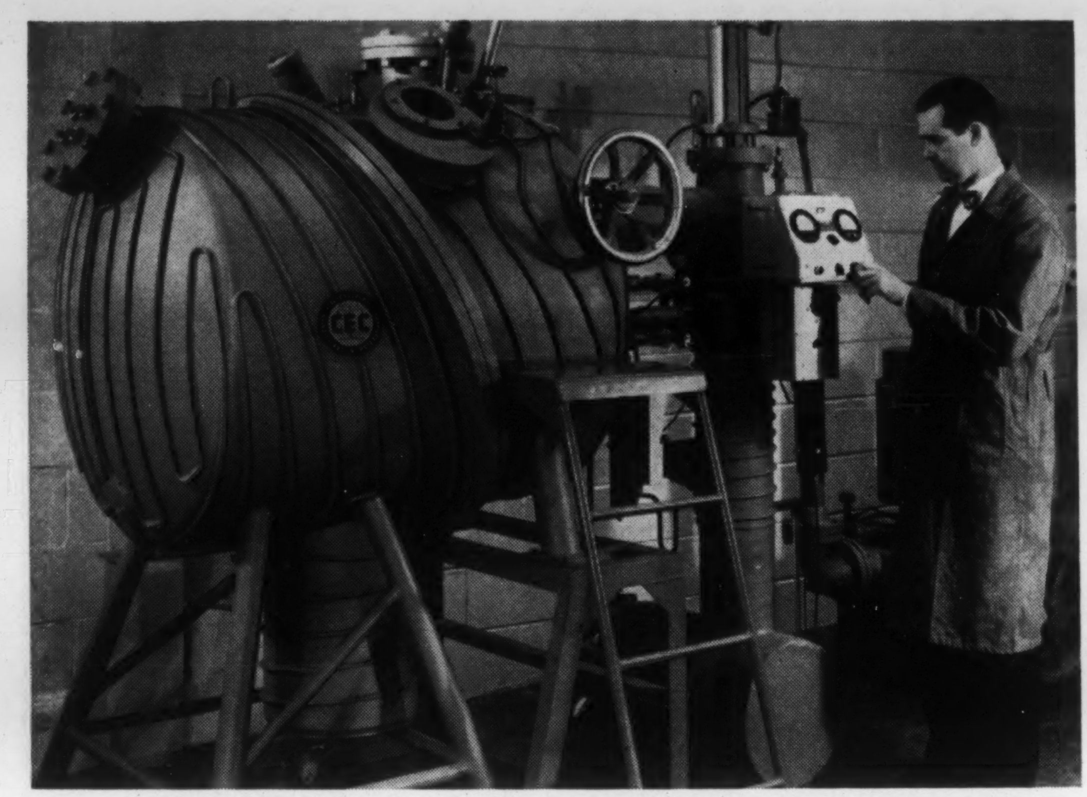
Meanwhile, Mallory-Sharon Titanium Corp. has announced that it has a new electrolytic refining process that yields extremely pure metallic titanium, and will build a large-scale pilot plant for evaluation of the new process.

Reclaim scrap?

According to James A. Roemer, president, the process has been "proved on a laboratory scale and several hundred pounds of ductile titanium have been produced." Although no details of the process have been revealed, Mr. Roemer says that many grades of scrap can be easily refined.

End product of the process is large crystals of extremely pure metal (see photo) formed on a steel cathode in a heated electrolytic solution. After refining, the crystals will be used in Mallory-Sharon's double-melting process for the production of large ingots.

Up to now technical difficulties and complicated handling have been responsible for the "lack of a market for titanium scrap. If the new process proves as attractive as it now appears," Mr. Roemer feels, "this scrap situation, affecting the entire industry, will be radically changed."



Process observation, alloy additions, pouring, temperature and pressure readings, high frequency control, valve sequencing—all focus around one center of operation.

Small but versatile

a high-vacuum furnace for lab and pilot plant

CEC's 5 to 50 pound melting and casting furnace offers:

Three-way casting: Melts of 5, 12, 17, 30, or 50 pounds can be cast in single or multiple molds—or centrifugally.

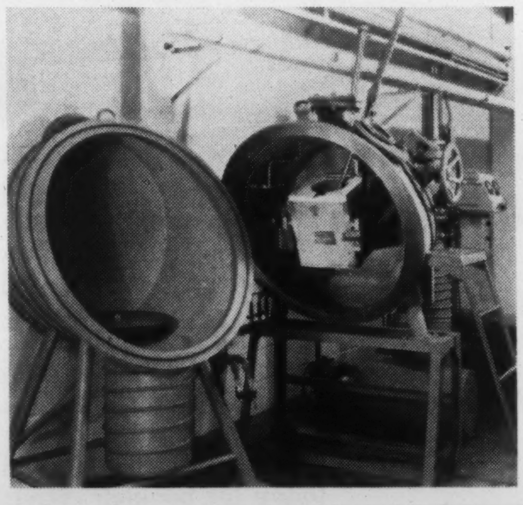
Ease of materials handling: All parts of the furnace interior are within arm's reach. The oblique angle flange connecting the chamber sections provides unusual vertical clearance for removing molds directly with a crane. A deep mold well provides 33" under the crucible lip for pouring bar-type ingots.

Complete controls: A manual bridge-breaker assembly is combined with a water-cooled, nonfogging sight tube for optical pyrometry. A sampling device and a thermocouple assembly are standard accessories. Interlocking of the pneumatic vacuum line valves makes for safe and proper cycling.

The mold well is water-cooled. Electric feedthroughs are provided for mold heating.

Ample pumping: A 2-stage diffusion-ejector pump brings the system swiftly to the low micron Hg pressure range, with plenty of reserve capacity for pressure surges from alloy additions, deoxidation, and pouring.

Write for illustrated bulletin No. 4-30 that lists complete specifications, accessories, and design features of this remarkably versatile furnace.



Open furnace shows crucible and coil assembly. Mold chamber has deep well and (optional) indexed table for multiple molds.

Consolidated Electrodynamics
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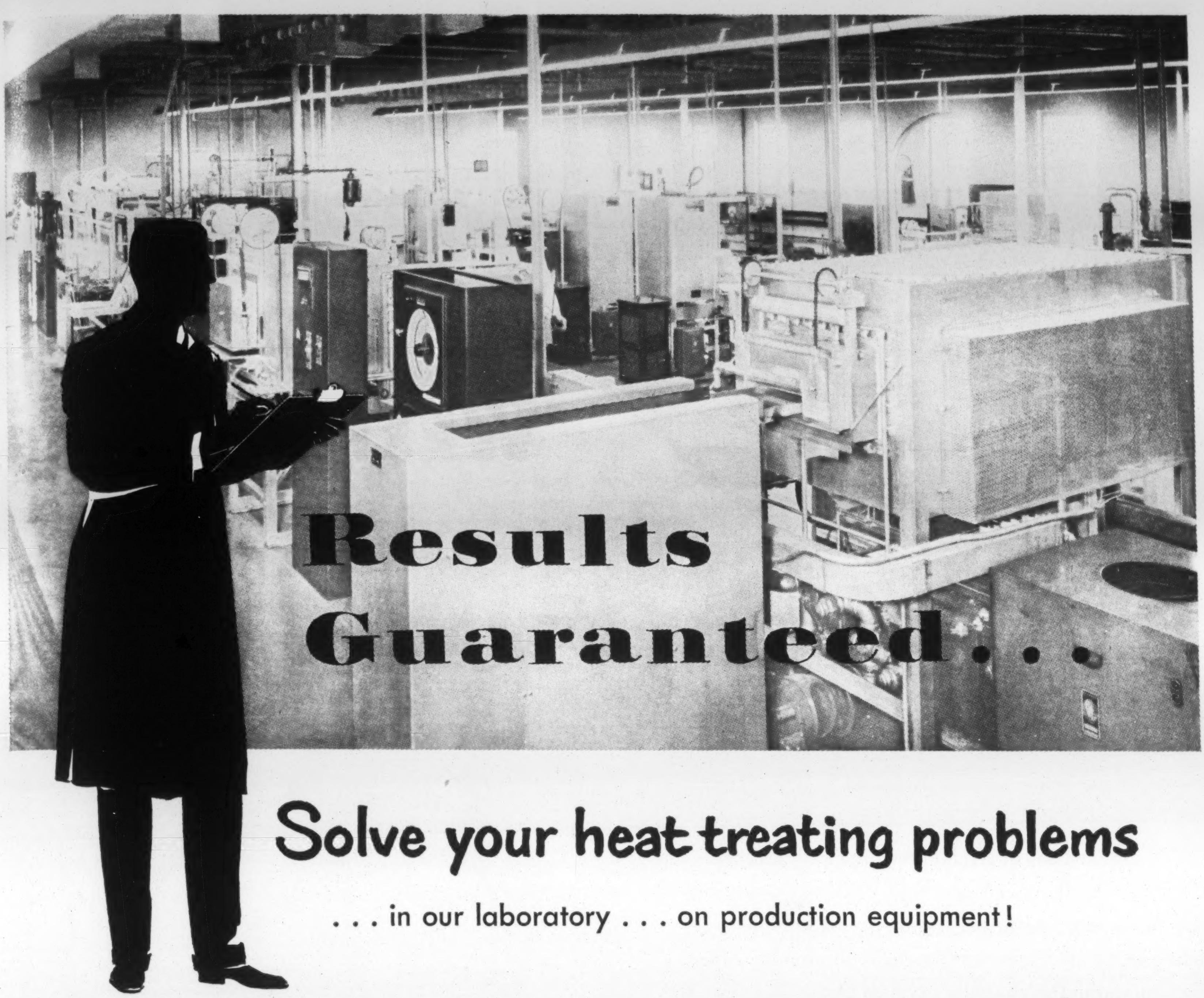

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Take an active part . . . see the actual results . . . of procedures and equipment developed to suit your specific needs. We feel that the Hayes Laboratory is unique in what it offers . . . GUARANTEED RESULTS!

Here's why:

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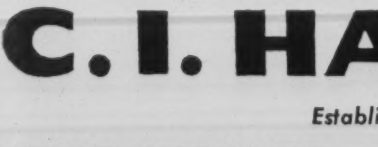
- You can use our laboratory facilities . . . and the services of our entire staff . . . WITHOUT COST OR OBLIGATION . . . because we know that those introduced to the superior features of the C. I. Hayes line become steady customers and good friends. Act today . . . for GUARANTEED RESULTS!



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City..*State*....................

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MAKE FAST WORK OF LIGHT-GAGE METALS with

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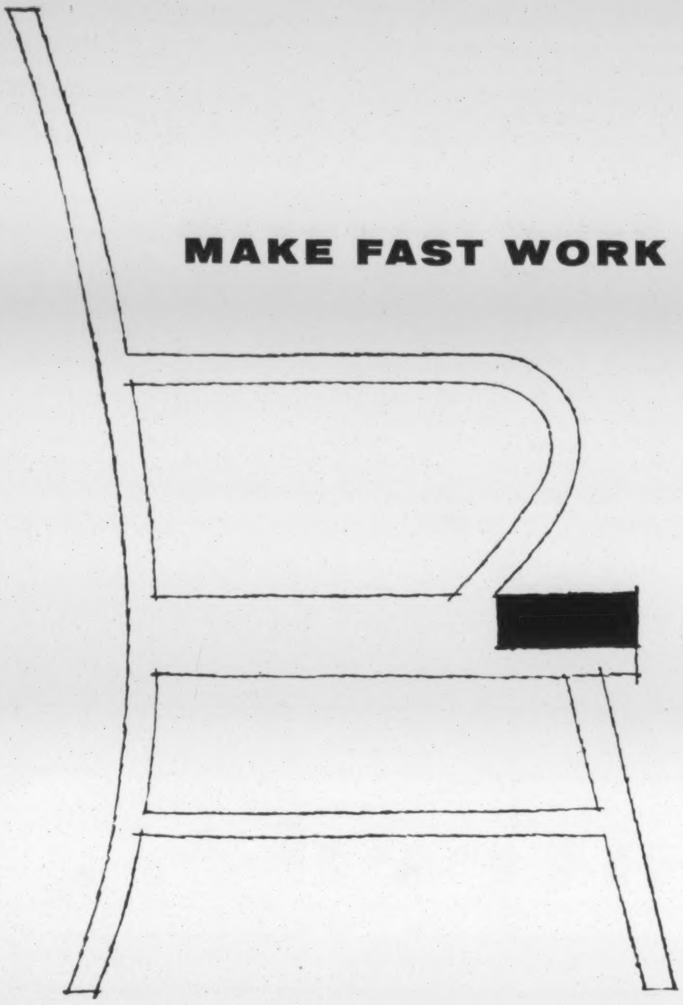
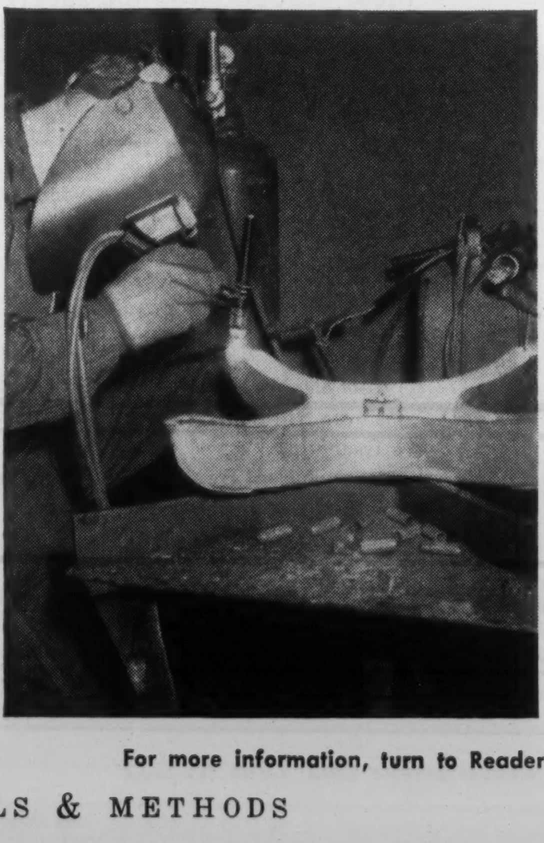
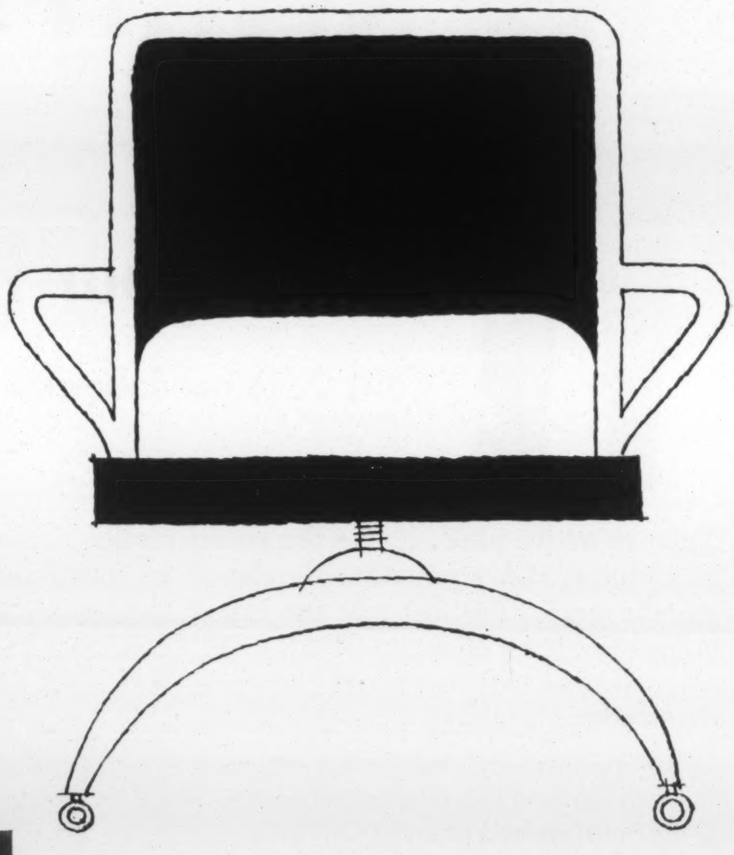


The combination of HELIARC welding's efficient argon gas shielding, localized arc heat, and wide range of easy-to-operate apparatus, is simplifying and speeding light-gage metal fabrication throughout industry. These modern aluminum chairs are typical of the many parts now fabricated faster and more efficiently than ever before—using HELIARC welding.

designed to meet needs . . .

HELIARC welding makes all types of joints on all commercially fabricated metals — at speeds up to 100 inches per minute. Manual, semi-automatic, and mechanized apparatus is easy to operate and maintain. Learn more about HELIARC welding — the most efficient process for a wide range of light-gage metal fabricating jobs. Contact your local LINDE representative today.





Modern, lightweight aluminum chairs are HELIARC welded in simple, cost saving operations.

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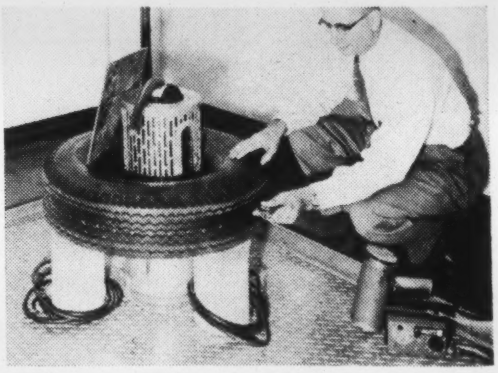
News OF INDUSTRY

Radioactive cobalt 60, *used in radiation experiments, glows in underwater shield. Aluminum housing (upper left) holds cobalt during irradiation.*



Rubber tire *is inspected following exposure to intense gamma radiation.*

Radiation Laboratory May Lead to Improved Rubber Products

■ A new laboratory especially designed for the exploration and development of rubber products that will perform satisfactorily in a radiation environment has been constructed by Goodyear Tire and Rubber Co.

Claimed to be the first of its kind in the rubber industry, the fully-equipped radiation laboratory will be used for such things as developing radiation resistant airplane tires for atomic powered aircraft; initiating synthesis polymerization and vulcanization of rubber; and improving physical properties of plastics and resins.

In pointing out the various ways in which the laboratory may benefit rubber research, Dr. R. P. Dinsmore, vice president in charge of Goodyear's research and development, suggests the possibility of commercially vulcanizing rubber without adding sulfur or other chemicals, and without raising temperature. Also, it may be possible to add monomers to a polymer already formed, endowing a rubber with selective, advantageous properties, such as resistance to certain types of solvents, low permeability to various gases, or lubrication, resulting in less internal friction and low heat generation from flexing.

The laboratory is a ground floor structure measuring 42 x 24 ft. Inside is a heavily shielded area known as the "cave," in which radioactive cobalt 60 is housed. An adjoining, well equipped physics and chemistry laboratory is used for the preparation of materials and test specimens and for the evaluation of results and products of irradiation experiments.

(more News on p 246)

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News OF INDUSTRY

Punch Cards Control Steel Rolling Mill

What is believed to be the world's first punch card-controlled steel mill is now turning out tons of metal daily at the Brackenridge Works of Allegheny Ludlum Steel Corp.

The control system, developed by General Electric Co., uses cards with certain areas punched out. These holes indicate the number of passes, the speed of rolling, and the sequence and amount of slab reduction. Because the rolling operation is performed the same each time, as predetermined by rolling experts, there is greater control of the quality of the steel. The rolled material is always of uniform size; and the steel from day to day has better, more constant physical properties.

The cards are given as many as 15 programmed passes and provide accuracies of about 1/100 of an inch. Six possible speeds are predetermined and recorded on the card. The mill has a maximum opening of 9.99 in. with a top screw-down speed of 40 in. per min.

A number of other mill applications for new and improved electronic techniques are also being studied by Allegheny Ludlum.

ASTE Meeting Features Nonmetallics

Latest developments in plastics and ceramic tooling will share the technical program spotlight when the American Society of Tool Engineers conducts its Silver Anniversary Program this month in Houston, Tex.

The plastics tooling symposium, co-sponsored by the Society of the Plastics Industry, will present the "most complete report yet compiled on the subject." Papers will deal with the history of plastics tooling, properties of plastics with respect to temperature changes,

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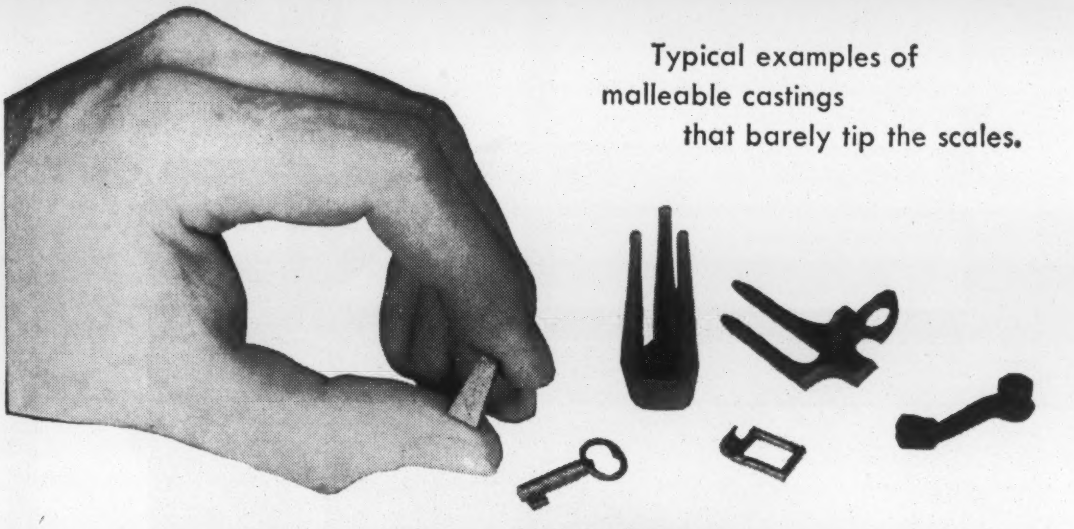


Typical examples of malleable castings that barely tip the scales.

A Pearlitic Malleable gear cover for use in 15 ton mine locomotive. Weight 111 lbs.

Many design problems—including even heavier parts—can be solved with malleable iron when you understand its widely versatile possibilities. Call a malleable foundry for information and suggestions, or write to the Malleable Founders' Society.

Malleable
FOUNDERS' SOCIETY

1800 Union Commerce Building
Cleveland 14, Ohio

For more information, turn to Reader Service Card, Circle No. 481

hardness, advantages and disadvantages of plastics tools and their effect on tooling expense.

The ceramic tooling symposium, co-sponsored by Massachusetts Institute of Technology, Ohio State University, and Warner and Swasey Corp., will cover latest research developments on ceramic cutting tools and attempts to adapt this new material to production problems. Papers will deal with resistance to softening under high temperatures, hardness, ease of forming, low coefficient of friction and low-cost availability.

Materials a Problem in Heavy Equipment

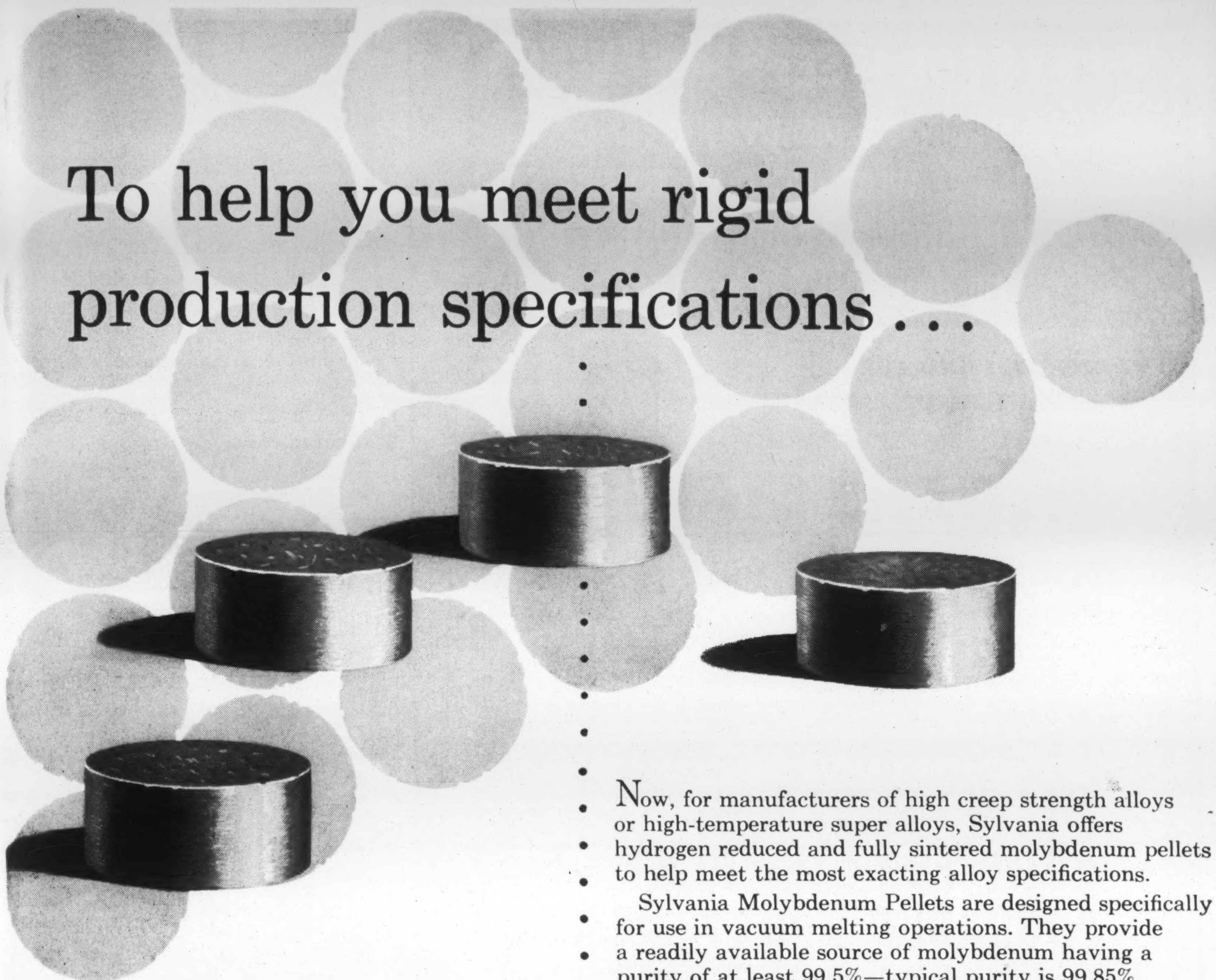
The trend toward heavier equipment puts an increasing burden on the designer responsible for materials selection, according to Lloyd E. Webb, chief metallurgist, Clark Equipment Co.

"The trend in materials handling and construction machinery design is definitely toward larger, more rugged machines," Mr. Webb said in a recent interview. "While this may be a boon for purchasers of equipment, it is bringing about a serious problem for designers and suppliers of materials.

"Limitations due to inadequate materials or lack of availability," he said, "restrict the freedom of the designer. Requirements for greater strength, power and load carrying capacity are necessitating use of some of the more recently developed materials, such as ductile iron and high strength steels. Consequently, the suppliers are being pushed for more and more information and development work on these new engineering metals."

Although most of the major problems in design of heavy duty materials handling equipment seem to be well under control, Mr. Webb says, "a continuing re-

To help you meet rigid production specifications . . .



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Sylvania Molybdenum Pellets are designed specifically for use in vacuum melting operations. They provide a readily available source of molybdenum having a purity of at least 99.5%—typical purity is 99.85%. This constant high purity simplifies the calculation of additions to each melt as the usual variations of purity and gas content are eliminated. By maintaining a high density, the gas content of the pellets is kept well below that acceptable for vacuum melting. In addition, the compact uniform size of the pellets (1″ in diameter by ½″ high) facilitates weighing and charging to the melt.

When you use Sylvania Molybdenum Pellets, you benefit in other ways, too. Their continuous availability means you can plan your production schedules on a long range basis. Further, their pricing stability permits you to price your own product without having to worry about fluctuating raw materials costs.

Your Sylvania sales engineer will be glad to discuss your molybdenum requirements or the high-purity tungsten available in sintered ingot form for vacuum melting. For further information, write to:

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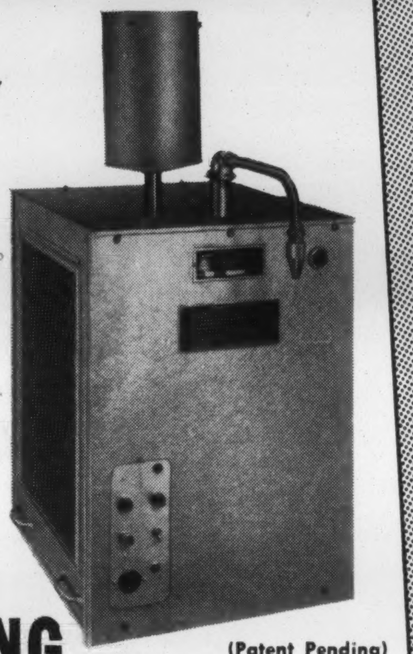

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search for higher strength metals . . . must go on. Realistic thinking on the part of the designer, materials engineer, supplier, and manufacturing and purchasing people will enable us to build tomorrow the machines that will do more work faster at less cost."

Metal Congress Meets This Month

Western sections of 36 prominent technical societies are cooperating with the American Society for Metals in sponsoring the 10th Western Metal Congress and Exposition, to be held Mar 25-29 in Los Angeles.

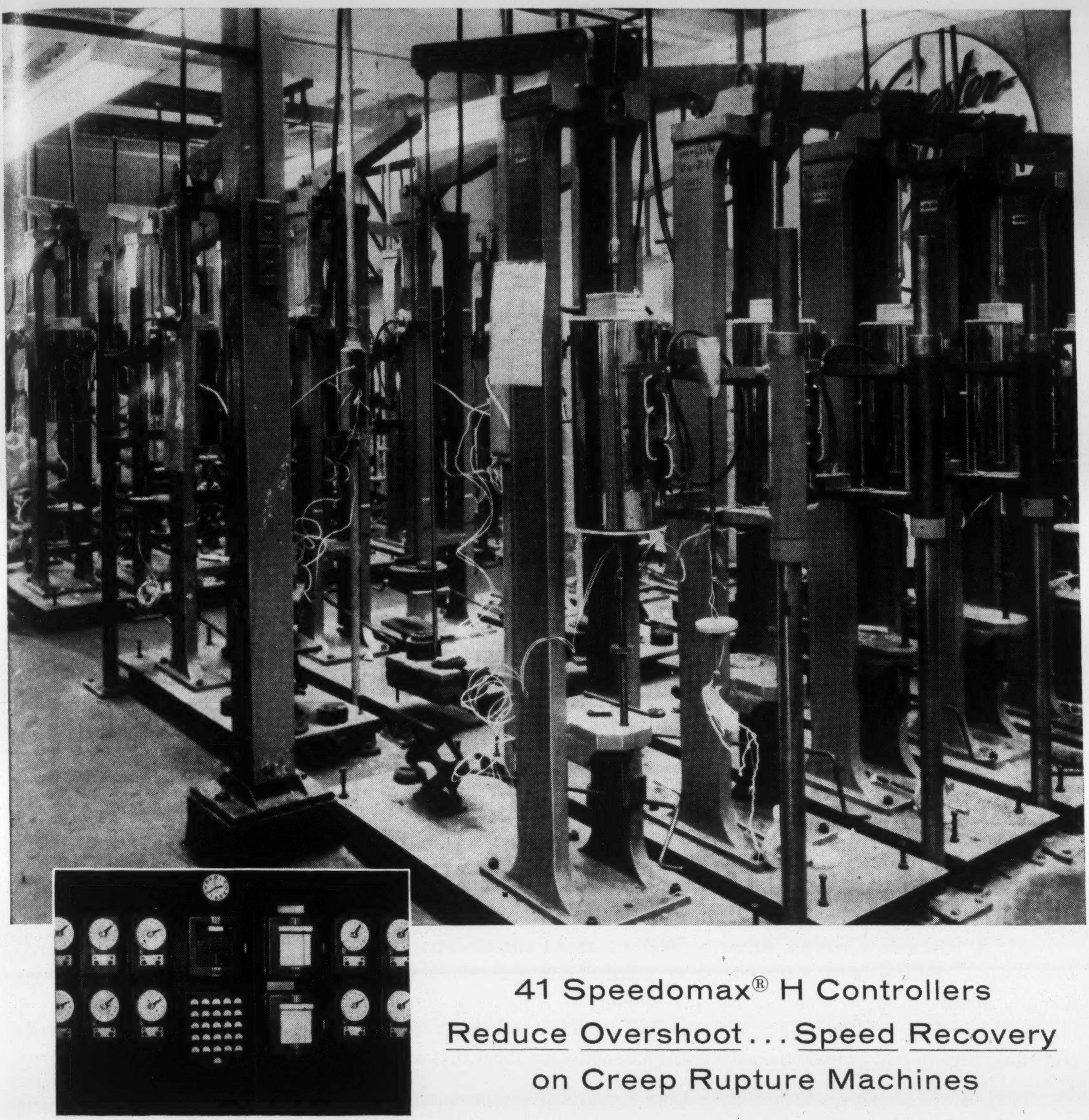
Papers covering outstanding developments in production of aircraft, missiles and electronics will be presented by American Society for Metals, American Welding Society, Society for Nondestructive Testing and the metals branch of American Institute of Mining, Metallurgical and Petroleum Engineers.

Following is a list of sessions scheduled:

ASM sessions—Titanium; aircraft and missile alloys for thermal flight; metals and metallurgy in electronics; special forming techniques; advanced machining methods of metal removal; short time elevated temperature testing of materials for the missile and rocket program; and corrosion and metal protection for the petroleum and chemical industries.

AWS sessions — Ultra-high strength weld metal for aircraft fabrication; an evaluation of filler materials for use on high strength low alloy steels; weldability of high temperature alloys; and high temperature silver brazing.

SNDT sessions — Nondestructive testing for the aircraft industries; nondestructive testing with isotopes; radiography and fluorescent penetrants; nondestructive testing in the nuclear energy field;



41 Speedomax® H Controllers
Reduce Overshoot . . . Speed Recovery
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Here are only some of the creep rupture machines and Speedomax controllers at Wyman-Gordon, Worcester, Mass. To meet government specs for jet plane forgings made of titanium and special alloy steels, Wyman-Gordon has installed 2 banks of creep rupture testing furnaces with space-saving Speedomax H proportioning control. This combination assures them of quality control on a production basis . . . permits them to turn out part after part which will meet the stresses induced in jet propelled aircraft.

To keep production moving, Speedomax H D.A.T. control enables operators to bring furnaces up to temperature in minimum time. Rate of approach, in most cases, eliminates overshoot . . . speeds recovery time after sample change. By continuously regulating heat input in proportion to furnace needs, this Speedomax H control holds temperature of furnaces within ±2 F and in addition, eliminates the need for manually readjusting auto transformers.

Additional instrumentation includes four multiple-point Speedomax G recorders for each bank of furnaces, and 80-point and 76-point Model D Speedomax G indicators for checking furnace temperatures at any time from a central location.

Why not investigate Speedomax H when installing your next heat treating furnace—whether it's electric or fuel-fired, continuous or batch. A phone call or letter to your nearest L&N office —or to 4925 Stenton Ave., Phila. 44, Pa.—will bring you more information.

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Instruments Automatic Controls • Furnaces

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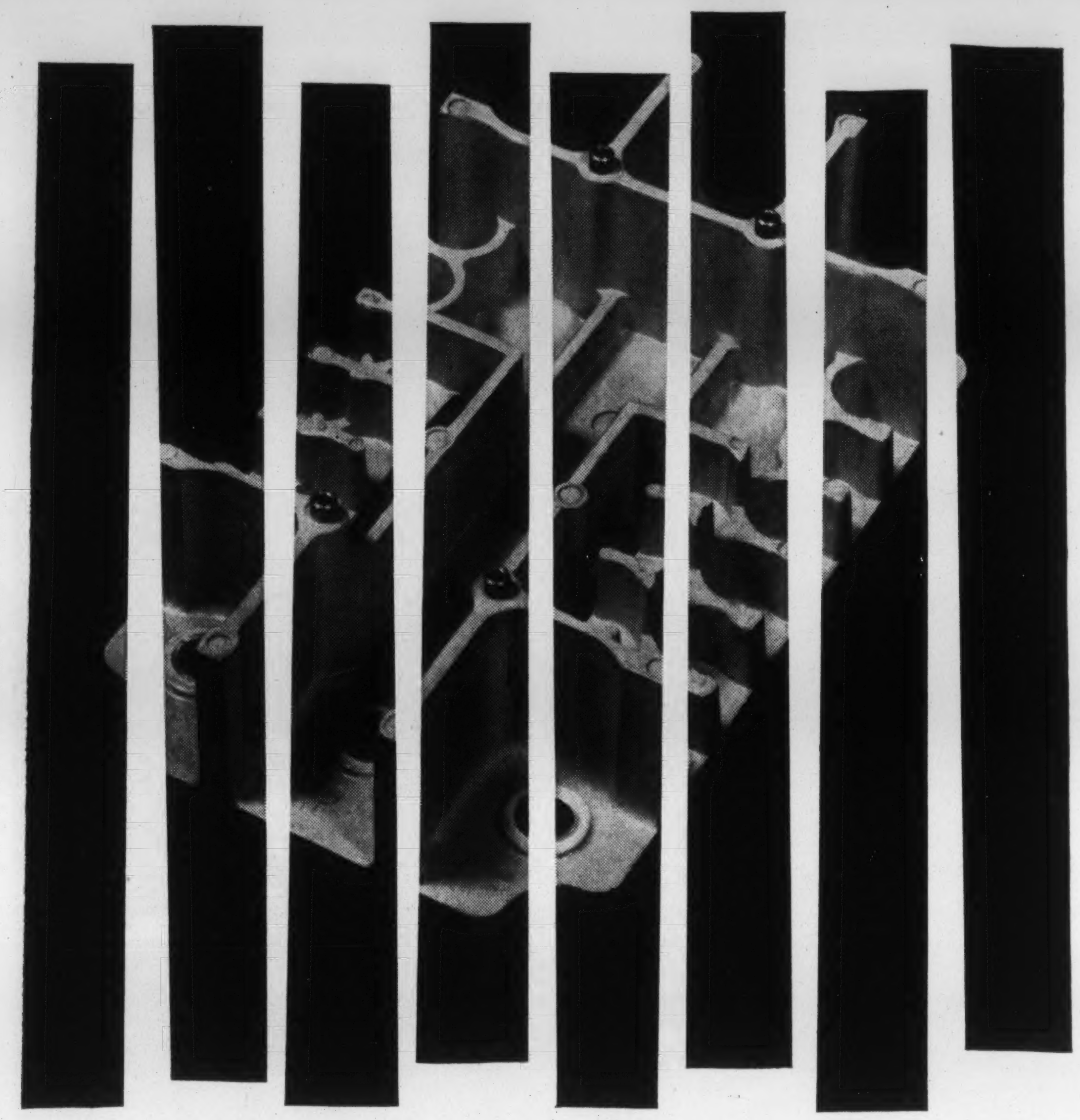

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These are the safeguards that make Kurz-Kasch delivery promises as reliable as you can get. Take the part shown above.

It meets a rather tight set of dimensional, physical, and electrical specifications, and it was shipped on a schedule that made the customer as happy as the performance of the part itself.

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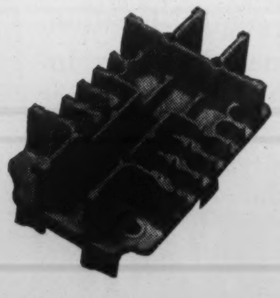

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and nondestructive gaging and quality control.

AIME sessions — Metallurgical problems in fabrication of high temperature air frames; performance of materials at elevated temperature for aircraft and missile applications; role of molybdenum in tomorrow's missiles; aluminum alloys for elevated temperature service; magnesium alloys for airframes.

Running concurrently with the above sessions will be a five day Titanium Conference presented by ASM's Metals Engineering Institute. Topics, among many others, include: titanium bolts; blanking and sheet metal forming; single point cutting; and Chemmilling.

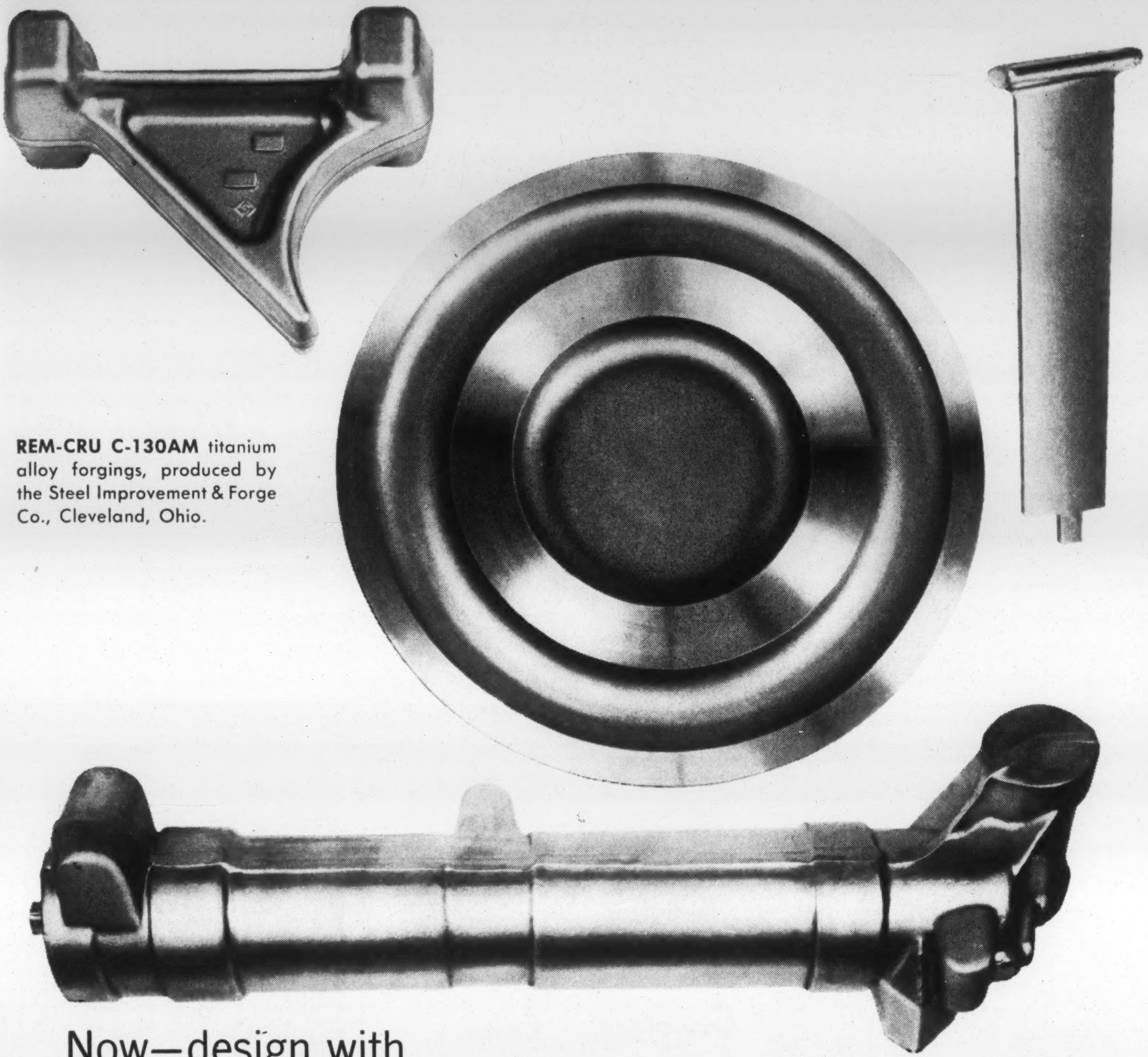
SPI Holds Annual Plastics Conference

"The Dynamic World of Plastics" is the theme of the annual National Plastics Conference being held this month in Los Angeles.

Sponsored by the Society of the Plastics Industry, Inc., and held in conjunction with the West Coast Plastics Exposition, the four day conference is directed at four important segments of western industry: aviation, electronics, packaging, and building and construction. Materials to be discussed include reinforced plastics, polystyrene foam, epoxies, linear polyethylenes, cellulosics and nylon. The conference runs from Mar 18 through 21.

Design Engineers To Meet in May

The second annual Design Engineering Conference, sponsored by the Machine Design Division of the American Society of Mechanical Engineers and held in conjunction with the Design Engineering Show, is unique in that it is the only conference devoted



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The advantages of REM-CRU titanium are so superior, you just can't afford to overlook them when designing new products. For down-to-earth suggestions on how to make the most profitable use of titanium, call a REM-CRU engineer *now*.

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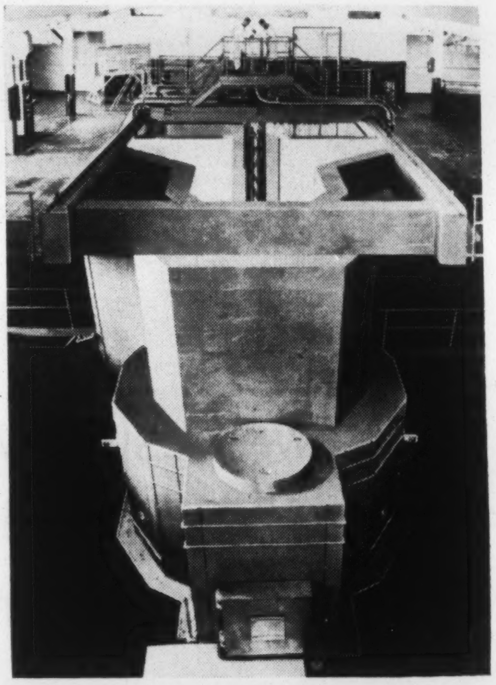
exclusively to the design engineer's needs. A program aimed at covering most of the mechanical, materials and electrical aspects involved in product design has been prepared by the editors of the four leading design publications (see M&M, Feb '57, p 247).

To be held in New York City May 20-23, the combined show and conference is expected to attract 20,000 engineers and executives.

One of the highlights of the conference will be two sessions devoted to engineering materials. Tentatively entitled "New De-



Research reactor With the completion at Battelle Memorial Institute of a one-million-watt research reactor, complete facilities for peacetime nuclear energy studies are now available to industry. The reactor, part of Battelle's privately owned nuclear research center, will be used, among other things, for the improvement and development of chemical, glass, plastics, ceramic and metallic products and processes.

The reactor uses solid uranium-235 fuel. The core, composed of fuel elements and boron control rods, is suspended 22 ft below the surface in a large pool of highly purified water. The water serves as a coolant and as a shield against radiation. The reactor is expected to operate six days a week, 24 hr a day.

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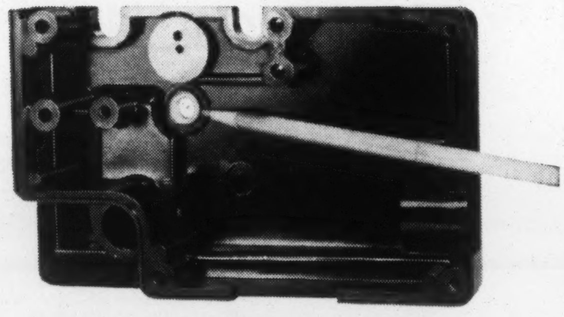

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NOW! ICE CUBES MADE *automatically!*

Combined molding of thermoplastic and thermoset materials helps assure trouble-free operation

If your next refrigerator is a Servel Icemagic, you'll find it solves the problems of ice-tray handling. It *eliminates* the tray—makes tumbler-round ice "cubes" automatically.

Part of the story behind this revolutionary development is a unique plastic part. It's made of phenolic—mostly, that is. However a small nylon bearing has been molded into the phenolic part. As a result, this self-lubricating nylon bearing allows the ice ejector arm to rotate freely . . . eliminates oil and any chance of ice contamination.

This was quite a trick . . . combining nylon and a phenolic. One's a thermoplastic; the other's a thermosetting plastic that requires molding heat that will normally soften a thermoplastic. To make a molding from both materials was like putting oil and water together. However, by selecting special formulations, and molding under mechanically contrived temperatures and conditions, Chicago Molded *did* the trick.

Whatever your new product needs, you'll find it pays to call in Chicago Molded. CMPC engineers *know* plastics, and they know how to help you make your product more saleable, yet less costly.

If you are interested in new plastic developments, let us send you a complimentary subscription to Plastics Progress. No obligation, of course.

CHICAGO MOLDED PRODUCTS CORPORATION
1026 North Kolmar Avenue, Chicago 51, Illinois

For more information, turn to Reader Service Card, Circle No. 421

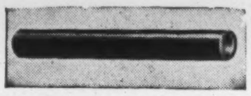
For more information, turn to Reader Service Card, Circle No. 384

TOUGH, resistant to chemicals, corrosion and abrasion, light in weight

SARAN

Champion of CHEMICAL RESISTANT MATERIALS Fabricated By PYRAMID*

*Licensee of Dow Chemical Co.

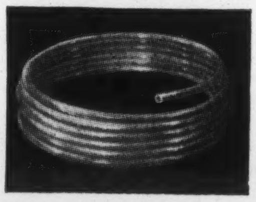


STOCK ITEMS

- Saran Pipe, Nipples and Fittings
- Saran Tubing, Tube Fittings
- Saran Sheets
- Saran Rods

SARAN MOLDED PIPE

Easy to use—can be cut with ordinary saw—threaded with standard pipe tools. Available IPS sizes ½" to 6". SARAN PIPE NIPPLES AND FITTINGS — light weight, strong, threaded for easy assembly. Standard sizes from ½" to 2".



SARAN TUBING

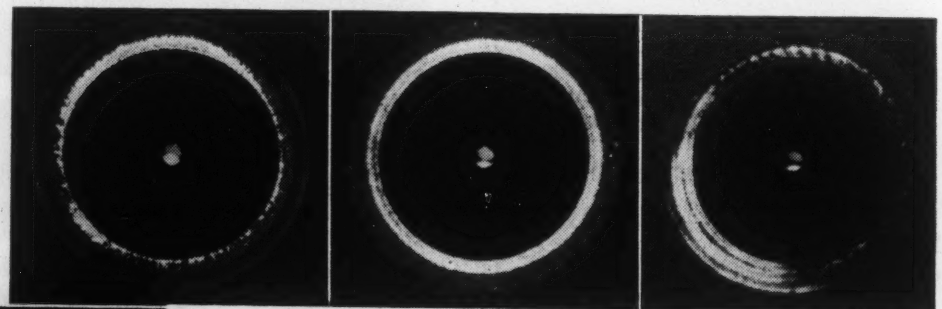
High bursting strengths, flexible, easy to handle. Resilient—will withstand rough usage under repeated vibration. Corrosive Resistant. SARAN TUBE FITTINGS—designed for high working pressures. Available from ⅛" to ¾".

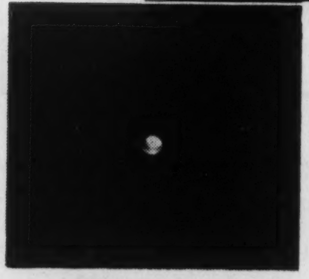
Write for new Pyramid bulletin—or send details for quotation.

PYRAMID PLASTICS, INC.

554 F West Polk Street • Chicago 7, Illinois

Proof . . . Armorhide outwears other coatings





Armorhide

New metal coating looks like leather and is ten times more abrasion resistant.

—colored, textured, and tough!

As demonstrated above, Armorhide is without equal in respect to abrasion resistance and general toughness of its film. Armorhide on a mil for mil basis will outwear conventional baked enamels by unbelievable margins. For example, Armorhide is ten times better than a wrinkle finish in abrasion resistance. The Taber Factor for Armorhide is 85 with c. s. 10 wheel for 1000 cycles. This figure compares favorably with the abrasion resistance of laminated vinyl film similar to products put out by the various rubber companies. Tests have been conducted for several years on products finished with Armorhide. The results of these field tests conclusively showed that Armorhide is superior in every respect to the highest quality baked enamels; so superior in fact that it could be compared only with the expensive vinyl and leather laminated on metal.

Write today for free booklet and sample panel.

JOHN L. ARMITAGE & CO.

ARMORCOID

Synthetic Enamels, Paints, Varnishes, Lacquers

245 THOMAS STREET • • • NEWARK 5, NEW JERSEY

For more information, turn to Reader Service Card, Circle No. 541

velopments in Engineering Materials," these sessions will include the following papers:

May 21—*Metallic Materials*, C. R. Simcoe, Metallurgical Engineer, Dept. of Metallurgy, Battelle Memorial Institute; *Ceramics and Refractory Materials*, John H. Koenig, Director, School of Ceramics, Rutgers University.

May 22—*Plastics and Rubber Materials*, Wyman Goss, Manager-Phenolics Engineering, Chemical Materials Dept., General Electric Co.; *Coatings and Finishes*, H. J. Reindl, Supervisor, Paint Section, Engineering Laboratory, Inland Mfg. Div., General Motors Corp.

Other sessions will cover design and application of gears and cams; selection of motors; and design of machines for automatic control. (See April and May issues of M&M for complete program, list of exhibitors and details of registration.)

Foreign Materials Featured at Trade Fair

Imported steel, aluminum, copper, brass and rare metals, as well as plastics, chemicals, rubber, petroleum products and other raw materials, will be featured in a special section of the United States World Trade Fair to be held in the New York Coliseum, Apr 14-27.

Approximately 3000 exhibitors from 71 foreign nations are expected to participate in the exposition. Other areas of interest include textiles, glassware, ceramics, building equipment and supplies, tools and electrical equipment.

Electrical Insulation

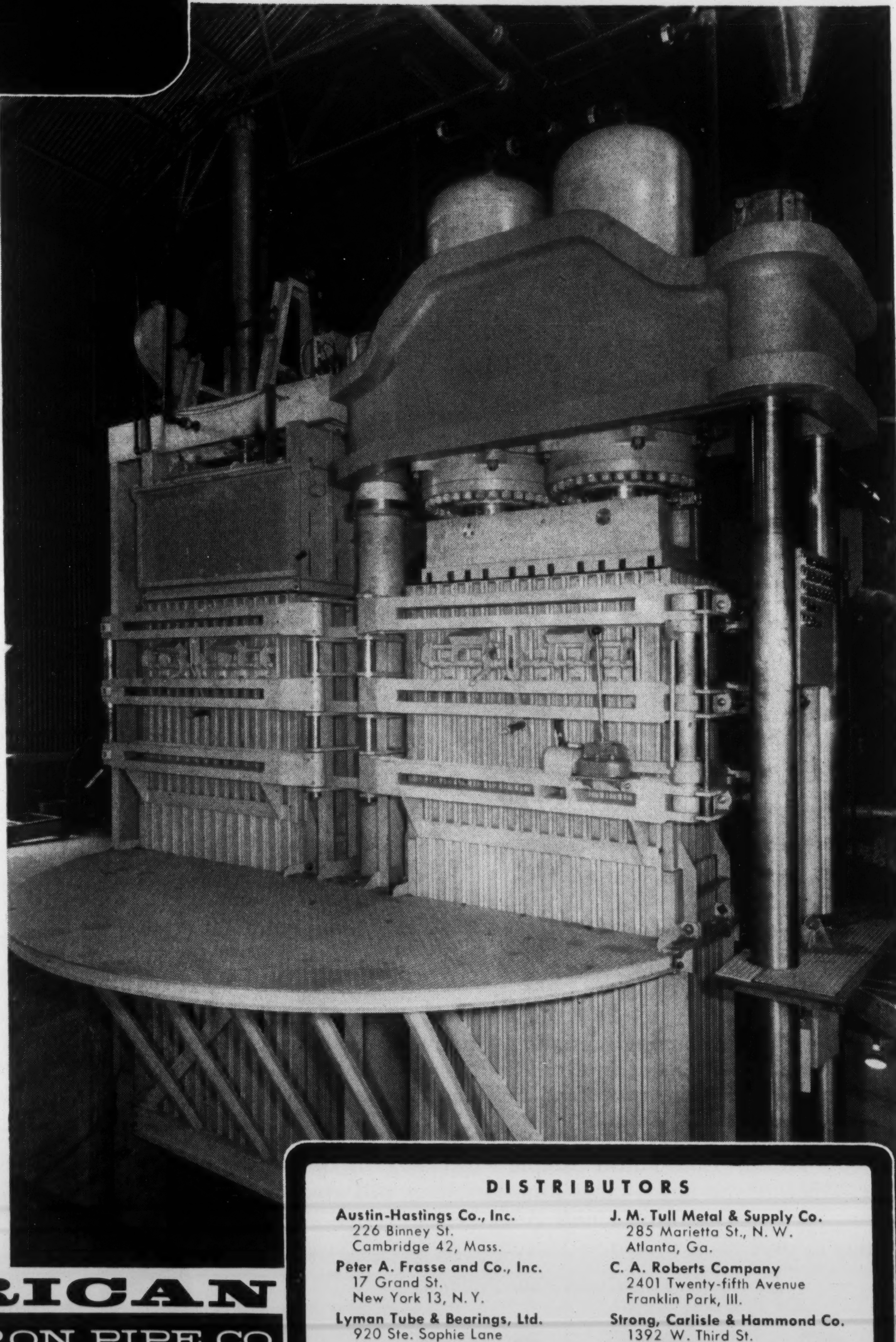
Coming in April

An authoritative 16-page survey of materials used for electrical insulation, with extensive data to aid in selection.

…"the most important since Eli Whitney"

Versatile ACIPCO

CENTRIFUGALLY SPUN Steel Tubes



"Delta" High Density Press, manufactured by Continental Gin Company of Birmingham, Ala. for a California cotton gin. Photo courtesy Continental Gin Company.

Designed for the cotton industry, this new hydraulic press permits an operational economy which has been called "one of the most important moves in the industry since Eli Whitney invented the cotton gin."

This press produces high density bales at the cotton gin, eliminating the need for extra compression of standard density bales before export shipment. Cotton bales from this press measure only 21″ x 23″ x 54″.

The first cotton baling press of its size, it operates at a hydraulic pressure of 2,000 psi, and exerts a total force of 1,650,000 pounds. Both of its main hydraulic cylinders were made from 23″ OD Acipco steel tubes.

Because they are centrifugally spun, Acipco steel tubes possess a uniform, highly dense, non-directional grain structure which is easier to machine, yet stronger and tougher. This quality, and others, can mean important economies in your application — both for you, and for your customer. Find out how by calling or writing your nearest Acipco distributor today.

SIZE RANGE: Lengths up to 16′ — longer lengths by welding tubes together. OD's from 2.25″ to 50″; wall thicknesses from .25″ to 4″.

ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels; plain carbon grades and special non-standard analyses.

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CAST IRON PIPE CO.
ACIPCO
Special Products Division
BIRMINGHAM 2, ALABAMA

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Austin-Hastings Co., Inc.
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Peter A. Frasse and Co., Inc.
17 Grand St.
New York 13, N.Y.

Lyman Tube & Bearings, Ltd.
920 Ste. Sophie Lane
Montreal 3, Canada

Vinson Steel & Aluminum Co.
4606 Singleton Blvd.
Dallas 7, Texas

J. M. Tull Metal & Supply Co.
285 Marietta St., N.W.
Atlanta, Ga.

C. A. Roberts Company
2401 Twenty-fifth Avenue
Franklin Park, Ill.

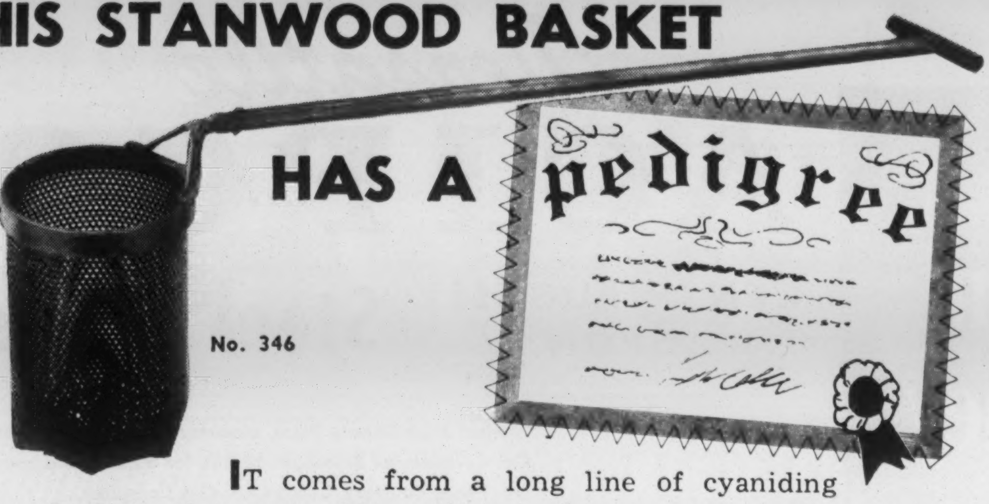
Strong, Carlisle & Hammond Co.
1392 W. Third St.
Cleveland 13, Ohio

Ducommun Metals & Supply Co.
4890 So. Alameda St.
Los Angeles 54, Calif.

For more information, turn to Reader Service Card, Circle No. 427

For more information, turn to Reader Service Card, Circle No. 522

THIS STANWOOD BASKET HAS A pedigree



IT comes from a long line of cyaniding baskets that were blue ribbon winners, until today Stanwood's are the "best of the breed." Stanwood has just the basket to efficiently and economically handle your parts through heat treating—every design based on long experience and skilled fabrication methods—hundreds of designs. If we don't have it, Stanwood engineers will design a basket specially for you. Write for catalog.

There's A Stanwood Representative Near You!

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BASKETS
TRAYS
CARBURIZING BOXES
FIXTURES

Stanwood Corporation
HEAT TREATING EQUIPMENT
4813 W. CORTLAND ST. CHICAGO 39, ILLINOIS

Roto-Finish processes give you
- tremendous savings
- high production
- uniformity of finish

Savings on deburring, descaling, grinding, polishing, coloring and surface improvement by Roto-Finish barrel finishing processes are tremendous. Expensive hand finishing can be eliminated.

Results Guaranteed! Send samples of finished and unfinished parts to Roto-Finish. Roto-Finish Sample Processing Laboratories will prove to you — before you buy — that Roto-Finishing will give you the results you want. Furthermore, Roto-Finish guarantees to produce the same results in your plant that are achieved in sample processing.

Let Us Help You with Your Problems

Roto-Finish COMPANY
3726 Milham Rd., Kalamazoo, Mich.
P. O. Box 988
Phone FI 3-5578

For more information, turn to Reader Service Card, Circle No. 548

News OF INDUSTRY

Engineers

R. J. Sullivan is now director of quality control, Vickers, Inc.

Don O. Noel has been appointed assistant to the president of Metals Disintegrating Co., Inc.

Charles E. Knox has been appointed manager of the newly created Process Engineering and Production Control Dept., Spring Div., Crucible Steel Co. of America.

Edward H. Perkins, Jr., has been elected vice president, Brooks & Perkins Inc.

Clayton DuBosque, Jr., has been appointed assistant to the executive vice president, American Machine & Foundry Co.

B. R. Teree has been appointed chief engineer, Greer Hydraulics, Inc.

William F. Cramer has been promoted to senior engineer, Armour Research Foundation, Illinois Institute of Technology.

S. D. Hackley has been appointed vice president, Kaiser Industries Corp.

Donald R. Grandy has been appointed engineering and technical consultant, Cleveland Div., Lindberg Engineering Co.

T. S. Pacer, E. B. Smiley and **G. P. Sullivan** have been named vice presidents, Illinois Gear & Machine Co.

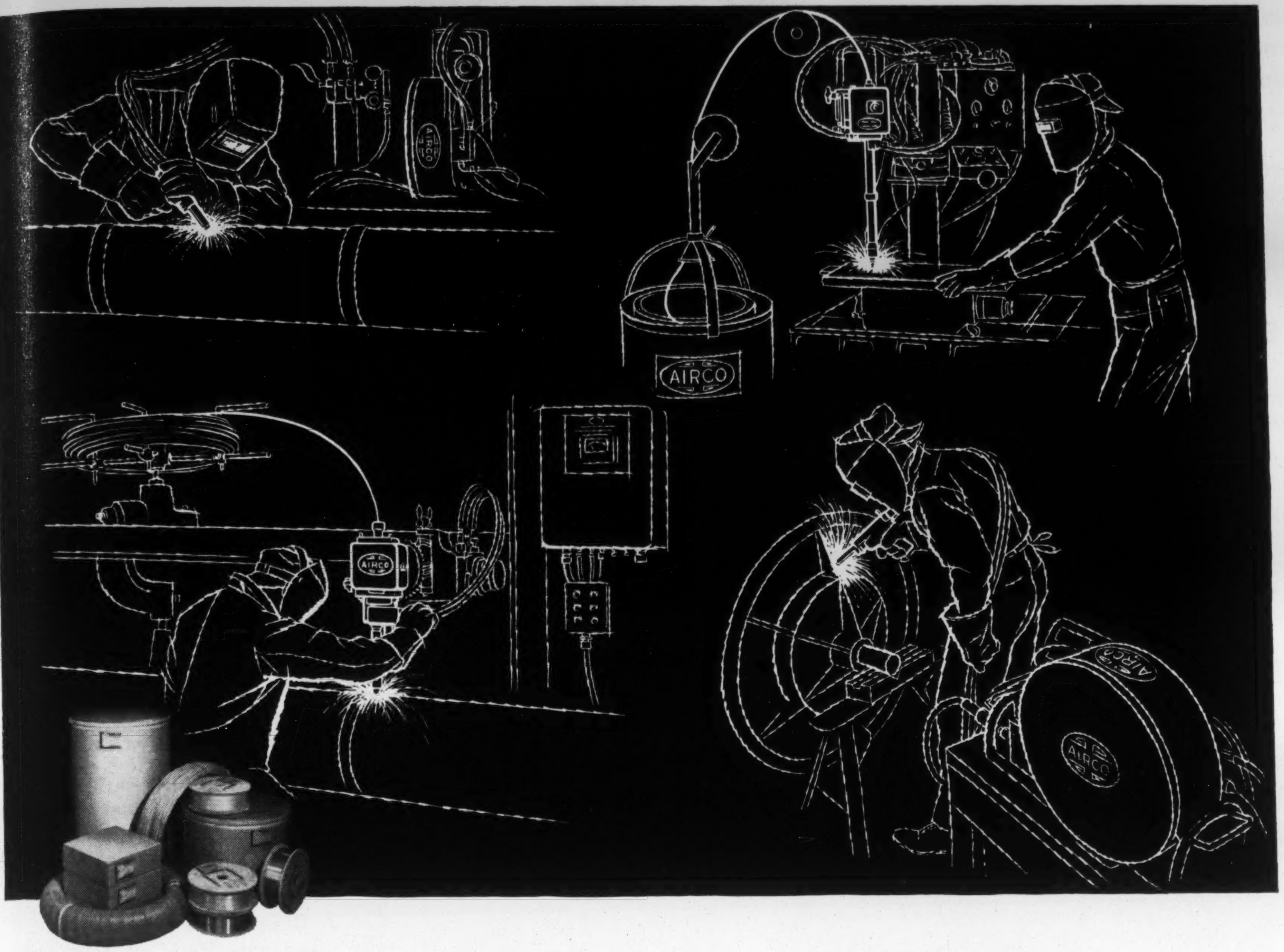
Bernard S. Reckseit has been appointed chief engineer, Ransohoff, Inc.

Robert E. Buckholdt is now manager of engineering, Selas Corp. of America. He was formerly vice president, Kendall Contracting, Inc.

R. J. Medkeff is chief engineer and **William Melas,** consulting engineer of Penn Instruments Div., Burgess-Manning Co.

Edward J. Mytkowicz has been appointed manager of operations, Hewitt-Robins, Inc.

H. F. Robertson is now manager-technical planning, Bakelite Co., a Div. of Union Carbide and Carbon Corp. He will be concerned with the



THE WIDEST SELECTION OF AIRCOMATIC® WIRE

for any kind of inert gas welding

Successful Aircomatic welding and Heliwelding (where filler metal is required) depend on using the correct wire. Airco can supply the widest variety of wire types and diameters — all specifically designed for use with these inert gas shielded welding processes. All Aircomatic wires meet rigidly controlled specifications as to chemical analysis, surface finish, purity, cast and packaging.

Pure . . . properly cast . . . level wound

Aircomatic Aluminum Welding Wires. New Type A finish available for all high-quality work where X-ray standards must be maintained . . . scrupulously clean . . . bright finish . . . properly wound . . . smooth surface assures trouble-free feeding.

Aircomatic Stainless Steel Welding Wires . . . excellent corrosion resistance . . . good tensile, ductility and impact properties . . . use to weld ordinary joints, apply stainless linings, build-up stainless overlays and join stainless overlays and join stainless clad materials.

Aircomatic Copper and Copper Base Alloy Welding Wires. Use to assemble copper bus bars . . . fabricate copper or bronze vats . . . build-up worn propellers, piston and valve parts . . . available in both solid and stranded types.

Aircomatic Steel Welding Wires. Three grades available for welding mild steel, armor plate and for overlays and welding hardenable steels.

Nickel base, magnesium, and titanium wires are supplied as specials. Consult your nearest Airco Office or Authorized Airco Dealer for complete information.

AT THE FRONTIERS OF *welding* ***PROGRESS YOU'LL FIND . . .*** AN AIR REDUCTION PRODUCT

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BOOTH 334 WELDING SHOW

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Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** — industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** — carbon dioxide — gaseous, liquid, solid ("DRY-ICE") • **OHIO** — medical gases and hospital equipment • **NATIONAL CARBIDE** — pipeline acetylene and calcium carbide • **COLTON** — polyvinyl acetate, alcohols, and other synthetic resins.

For more information, turn to Reader Service Card, Circle No. 501

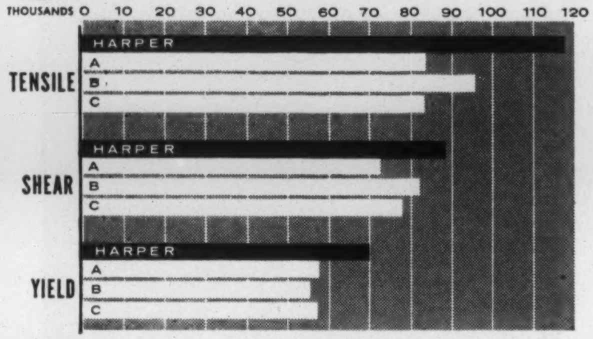
HARPER®

Immediate delivery from 150,000,000 standard items in Stainless, Monel, Aluminum, Brass, Bronze, Copper!

Thousands of Harper corrosion-resistant fastenings are in Harper Distributor stocks across the country! Even more thousands are continually on hand at The H. M. Harper Company for your convenience! A phone call to your Harper Distributor will do the trick! Why shop? Why wait? For immediate delivery, specialized service—call your Harper Distributor now!

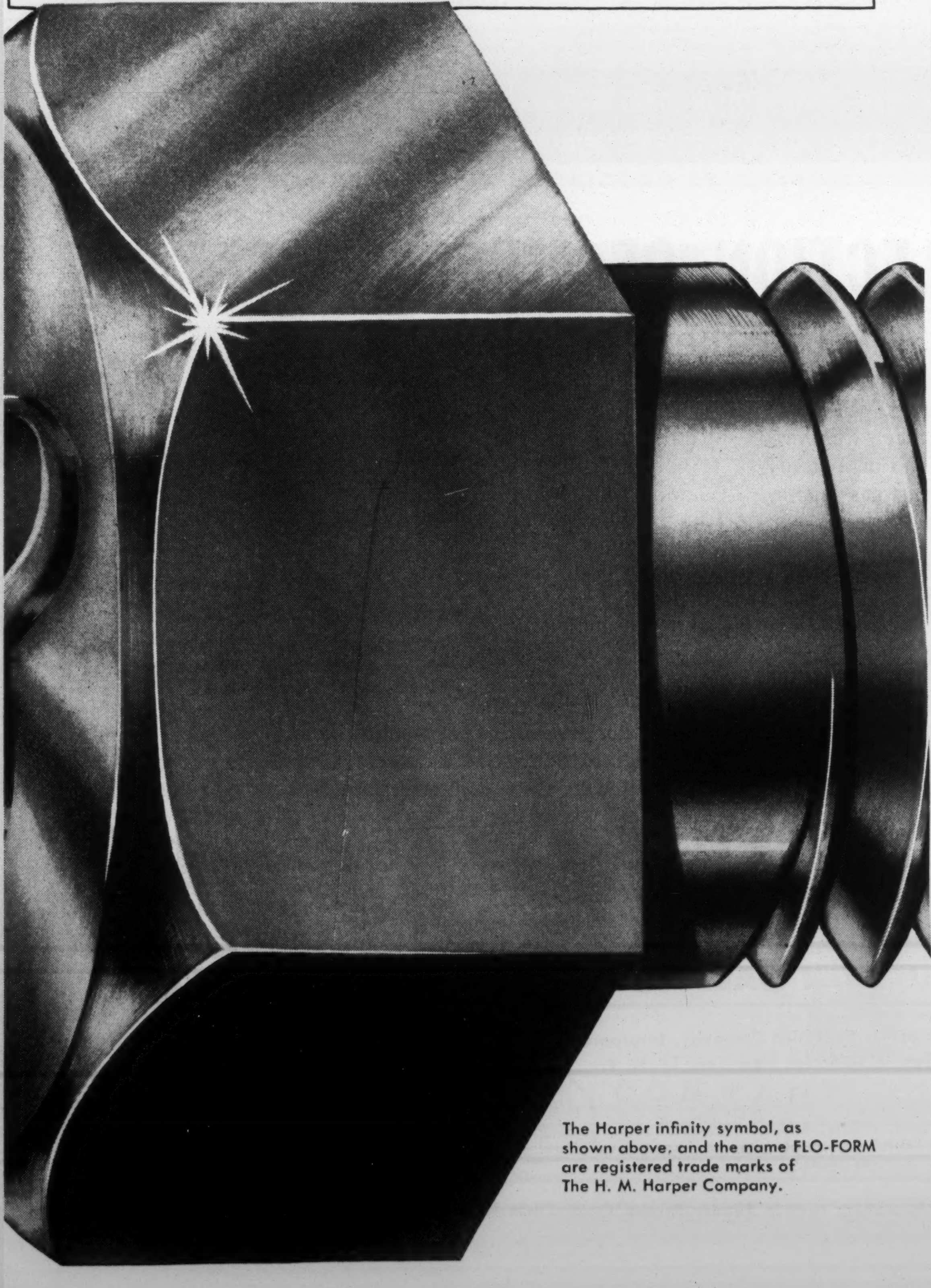
THE H. M. HARPER COMPANY
8201 LEHIGH AVENUE • MORTON GROVE, ILLINOIS

Irrefutable proof of Harper's greater metals' strength shown by laboratory test!



An important point in buying fastenings is strength. Independent laboratory tests*, utilizing Stainless Steel Machine Bolts by Harper and three other leading producers, prove Harper superiority in Tensile, Shear, and Yield Strength. The chart at left shows the actual results of these tests. For complete information on these important tests, request Form No. 126.

*By R. W. Hunt Laboratories



The Harper infinity symbol, as shown above, and the name FLO-FORM are registered trade marks of The H. M. Harper Company.

News OF INDUSTRY

future and long range effort of the Research and Product Process Development groups.

John R. Duffy has been appointed chief engineer, Lindberg Engineering Co.

Dr. R. B. Corbett has been appointed director of metallurgy, Midvale-Heppenstall Co.

Richard E. Dunning has been elected vice president in charge of manufacturing, Logo, Inc.

Charles Liechti has been appointed chief engineer, Technical Services, Eutectic Welding Alloys Corp.

C. G. Stupp has retired as vice president of Barrett Div., Allied Chemical and Dye Corp. Dr. Maurice H. Bigelow will assume Mr. Stupp's responsibilities.

Leo J. Brancato has been appointed vice president, Heli-Coil Corp. He will continue to head the Engineering Dept.

Max C. Farmer has been appointed to the newly created position of technical director, Beryllium Corp.

Comfort A. Adams, Harvard Professor Emeritus, has been awarded the 1956 Edison Medal by the American Institute of Electrical Engineers. Prof. Adams is the oldest living past president of AIEE.

Walter C. Chaffee has been named director of engineering and **Lester B. Harrington** chief engineer, Bennett Pump Div., John Wood Co.

John P. Poth has joined Bullard Co. as director of engineering.

Lyman A. Bliss succeeds **Kenneth Rush** as president of Union Carbide Nuclear Co. Mr. Rush will continue to have over-all responsibility for Union Carbide and Carbon Corp.'s nuclear and international activities as a corporation vice president.

Carl A. Vill, formerly director of engineering, has assumed the duties of assistant to the vice president of Chemical Construction Corp., a subsidiary of Electric Bond and Share Co.

Lesten V. Taylor has been named senior product engineer, Research

◄ For more information, Circle No. 467

and Development Dept., Crown Cork & Seal Co., Inc.

Alan **R. Pearlman** has joined Universal Atomics Corp. as chief engineer.

F. L. Griffith and **F. W. Blanchard** have been elected vice presidents of Hewitt-Robins, Inc.

Paul M. Brister has been advanced to manager, Engineering Design Section of Babcock & Wilcox Co. **William D. Stevens** succeeds Brister as Engineering Dept. coordinator.

Dr. Clarence Zener assumes the post of director, Westinghouse Research Laboratories, after five years as an associate director.

Donald I. Bohn, designer, inventor and engineer in the electrical and power generation field, has retired from Aluminum Co. of America after more than 34 years of service.

John P. Zur recently joined Sunbeam Corp. as a senior engineer with the Industrial Furnace Division.

George F. Hodgson is assistant chief engineer, Doehler-Jarvis Div., National Lead Co.

Dr. Wilbert A. Taebel has been appointed engineering manager, Lamps Parts Dept., Westinghouse Lamp Div.

Dr. B. D. Thomas succeeds **Dr. Clyde Williams** as director of Battelle Memorial Institute; Dr. Williams continues as president of the Institute.

E. W. Fisher heads the new Product Engineering Dept., Garlock Packing Co.

John E. Stockton has been appointed senior system and procedures analyst in the Organization and Methods Planning Dept. at Federal Telecommunication Laboratories, International Telephone and Telegraph Corp.

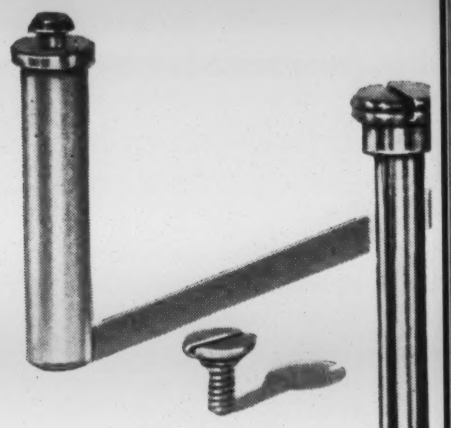
Joseph H. Cadieux, former manager, Detroit Plant, Misco Precision Casting Co., has been appointed vice president of manufacturing. **Freeman M. Jones,** former administrative manager, is now administrative vice president.

(News of Companies on p 282)

For more information, Circle No. 475 ➤

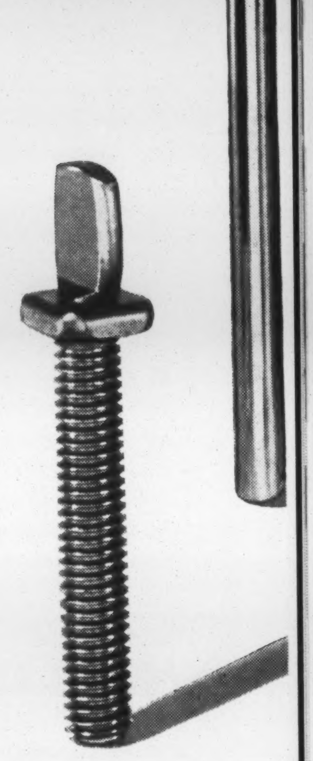
HARPER®

CORROSION-RESISTANT FASTENINGS



SPECIAL PARTS? Harper's exclusive Flo-Form Process solves these problems at big savings!

There's no part too tiny, too large, or too complex for Harper Flo-Form! This remarkable process could only be developed by Harper, with its wealth of thirty-three years' experience in corrosion-resistant fastenings. Where others mill from bar—Harper Flo-Form produces by cold or hot forging under tremendous pressures. The results?—a *better* product, *faster,* at *lower cost!* Place your "special problem" in the hands of the Harper Flo-Form team of design engineers, metallurgists, and tooling specialists. Write Harper, or call your nearby Harper Branch for Harper Application Engineering Service. Your problem is *our* problem.



THE H. M. HARPER COMPANY

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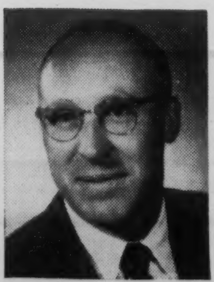
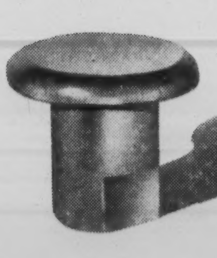
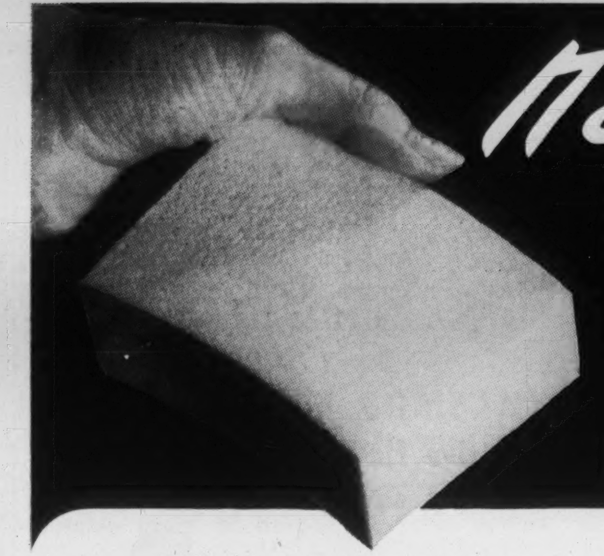


Meet Harper Application Engineer, LEON HAMLET

Every day sees new special parts problems submitted to Mr. Leon Hamlet of the Harper Branch in Milwaukee. Mr. Hamlet in turn, works with the Harper Flo-Form Engineering Team to provide the *right answer* at the *lowest possible cost.*



For more information, turn to Reader Service Card, Circle No. 546



IT'S NEW . . .

AGILENE-F
Expanded Foam Polyethylene now processed and molded to your specifications

Non-Toxic and Odorless AGILENE-F Gives Industry a New Corrosion and Chemical Resistant Engineering Material.

■ Exhibiting the same high chemical and corrosion resistance as conventional polyethylene, AGILENE-F can be processed and molded for literally dozens of industrial applications from simple gasketing to automotive applications. Available in semi-finished molded components as rings, blocks, sheet or rod, it can be molded to meet your specifications. AGILENE-F is available also in densities from 10 to 50 lbs. per cubic foot, specific gravity of .46 or .33, and tensile strength of 500 to psi. This material is unicellular, light weight, buoyant and has excellent compressibility, AGILENE-F can be worked with common wood or metalworking tools — sawed, drilled, machined, hot gas welded, friction and heat welded.

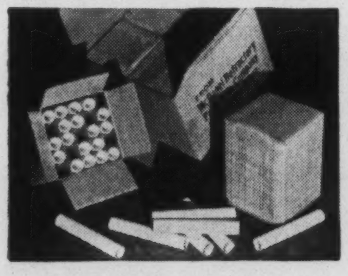
Write for detailed literature and prices.

AGILENE AGILIDE

AMERICAN AGILE Corp.
5461 Dunham Rd. • Maple Heights (Suburb of Cleveland), Ohio

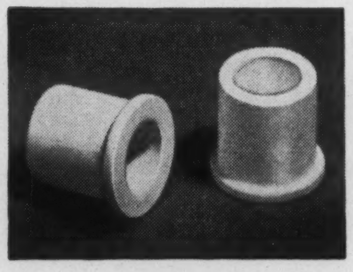
McDANEL

COMBUSTION TUBE ACCESSORIES . . .
PROLONG TUBE LIFE—KEEP ANALYSIS FINDINGS CONSTANT



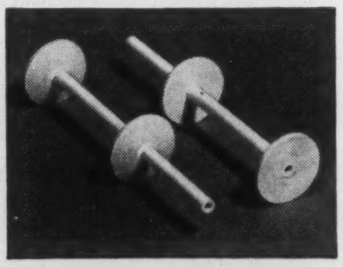
INSERT LINERS

• Thin, porous walls for immediate heat penetration. Protect tube from metal spatter. No adverse effect on analysis. Chamfer for easy boat insertion. Carefully inspected . . . 25 to carton, 4 cartons to case. Inexpensive!



ADAPTERS

• Bushings for centering tube in standard 2" diameter furnace opening. 2" O.D. with 2-3/8" diameter by 1/4" thick flange. I.D. to fit tube. Prevent tube breakage due to vibration and centers tube in heat zone.



HEAT REFLECTORS

• Assist in concentration of heat on sample in boat. Protect stopper from heat. Permit full gas flow. Provide sliding fit in standard combustion tubes. Hose connection is 5/16" O.D. with 1/8" bore.

McDANEL Industrial CERAMICS

McDANEL
REFRACTORY PORCELAIN COMPANY
BEAVER FALLS • PENNSYLVANIA

Send for Bulletin C1-55 on Combustion Tubes and Accessories.

For more information, turn to Reader Service Card, Circle No. 401

News OF INDUSTRY

Companies

American Electronic Laboratories, Inc. has moved its main administrative offices to 121 North 7th St., Philadelphia, Pa.

Air Reduction Sales Co. has acquired the assets and business of Jackson Products, Inc., a manufacturer of electric arc welding supplies.

Standard Pressed Steel Co. is building an addition to its Hollowell Steel Shop Equipment Div. at Jenkintown, Pa.

General Electric's Metallurgical Products Dept. has constructed a carbide metals shop at Kenilworth, N. J.

Misco Fabricators, Inc., a division of Michigan Industries Co., has moved to Marysville, Mich., 45 miles north of its old Detroit location.

Evans Research and Development Corp. has joined the American Council of Independent Laboratories, Inc.

Arnold Magnetics Corp. has moved to new and larger quarters in Los Angeles.

Surface Combustion Corp.'s Industrial Divisions will add a new engineering building to their Toledo facilities to increase existing design capacity by 30%.

American Hard Rubber Co. has purchased the capital stock of **Electric Manufacturing Co.**

United States Rubber Co. has started work on a new building that will provide additional manufacturing, warehouse and office space for its power transmission belt plant in Philadelphia.

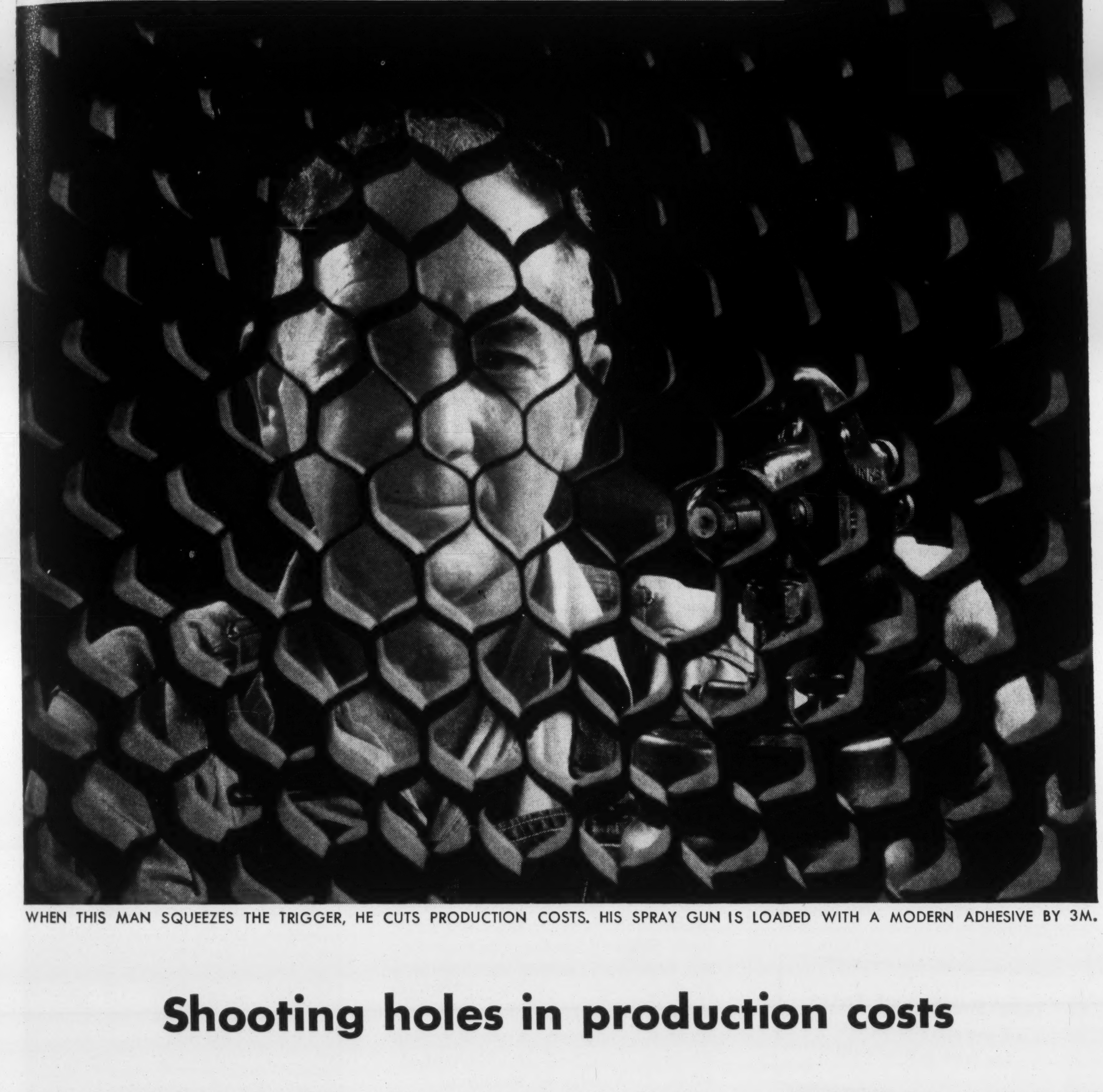
McGraw Electric Co. has acquired the assets of **Thomas A. Edison, Inc.** The consolidated company will be known as McGraw-Edison Co.

Frigikar Corp. has acquired and will operate the **Reliance Engineering and Mfg. Corp.** as a wholly owned subsidiary.

Kaiser Aluminum & Chemical Corp. has purchased the wire and cable business of **United States Rubber Co.**

Ryan Aeronautical Co. is constructing a new engineering and labora-

See what adhesives are doing today!



WHEN THIS MAN SQUEEZES THE TRIGGER, HE CUTS PRODUCTION COSTS. HIS SPRAY GUN IS LOADED WITH A MODERN ADHESIVE BY 3M.

Shooting holes in production costs

Every day this worker shoots holes in his company's manufacturing costs. The 3M adhesive in his spray gun creates a structural sandwich that's inexpensive, featherweight and strong. Naturally this adhesive is a favorite with the comptroller.

3M adhesives like EC-1357 and EC-1177 bond a honeycomb paper core between thin metal skins. They produce rigid, more durable units from such light materials because they're tougher, more flexible. Many industries benefit: building, furniture, aircraft, railroad equipment and others.

These 3M adhesives are specially designed for this sandwich construction, thoroughly tested. They apply fast and easily, like the hundreds of varied 3M adhesives for other uses.

SEE WHAT ADHESIVES CAN DO FOR YOU!

Consult 3M research. Contact your 3M Field Engineer. Or for information and free literature write on your company letterhead to: 3M, Dept. 83, 417 Piquette Avenue, Detroit 2, Michigan.

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3M
RESEARCH

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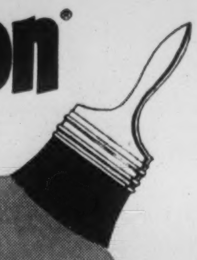

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tories building next to its present main office building in San Diego.

Bart-Messing Corp. and **Sel-Rex Corp.** have merged under the name Sel-Rex Corp. Plans call for the centralization of manufacturing and laboratory facilities.

W. S. Shamban & Co. has enlarged its Culver City, Calif. plant and built a new plant in Fort Wayne, Ind.

National Bureau of Standards has established a Dielectrics Section. The new unit, to conduct fundamental investigations on the dielectric properties of matter, will be headed by Dr. John D. Hoffman. Specific areas of research will include polymeric systems; direct current conductivity of dielectrics; methods of increasing the accuracy of dielectric measurements on solids, especially at audio and lower frequencies; and fundamental studies on molecular and ionic crystals.

Societies

American Society of Tool Engineers has elected James R. Weaver, Westinghouse Corp., as chairman of the Research Fund Committee.

Investment Casting Institute, at its fourth annual meeting, presented awards to the following: Kenneth M. Bartlett, Horizons Inc.; Ted Operhall, Misco Precision Castings Co.; Dr. Nicholas J. Grant, Massachusetts Institute of Technology; Roger Waindle, Wai Met Alloys Co.; Edward G. Chapman, Misco Precision Castings Co.; and Dr. Richard A. Flinn, University of Michigan.

Society of Automotive Engineers has elected W. Paul Eddy, chief of engineering operations, Pratt & Whitney Aircraft Div., as president.

Society of Plastics Engineers has elected the following national officers for 1957: president—Peter Simmons; vice president—Hi Nathan; secretary —Ken Gossett; treasurer—Jules Lindau, III.

American Die Casting Institute has announced that nominations for the annual Doehler Award should be submitted before April 15. The

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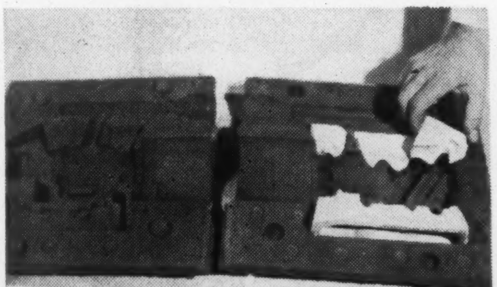
in casting stainless steel jet afterburner components

Cooper Alloy Advanced Casting Know-How Solves Alignment Problem, Cuts Machining Costs For Pratt & Whitney



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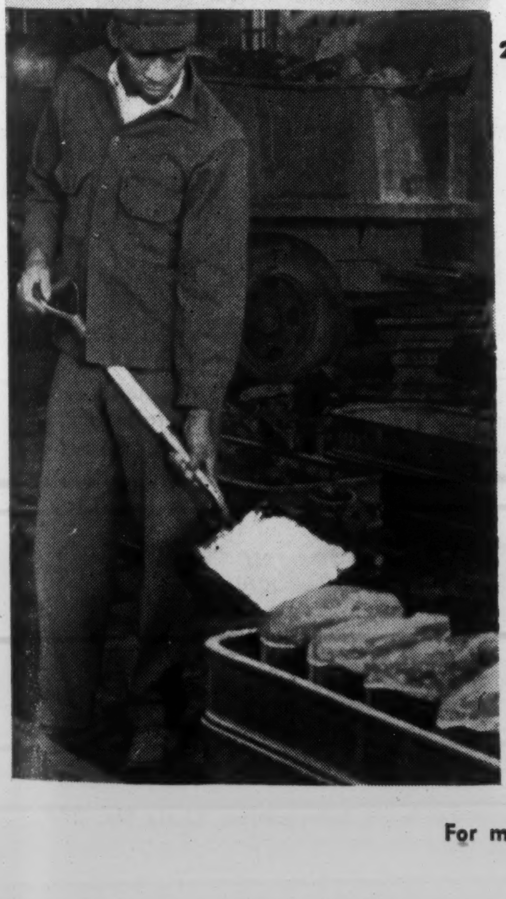

2

PROBLEM: To produce precise tolerances on this complicated jet igniter afterburner valve casting for Pratt & Whitney Aircraft. Previous method involved use of core mold and five cores. Core shifting was the main problem as off-symmetry pieces caused a serious and costly problem of machining. Troubles were further accentuated in that the alloy (a very brittle material) was non-repairable. With welding impossible and 100% X-Ray and Zyglo required, defects could not be tolerated.

SOLUTION: (a) Development and use of 4 shell cores, all placed in one half of the mold and in an unmovable position, overcame problem of shifting and held close tolerances (Fig. 1). (b) Use of Shellcast® process gave a better surface finish with no defects. (c) To prevent mold deflection and loss of dimensional accuracy from weight of metal, shell molds were backed up with a special sand (Fig. 2) which hardens immediately when gassed with carbon dioxide.

Since making the change to shell molds and cores, and with the use of the CO_2 process, accuracy and finish are excellent. In overcoming core and mold shifting by the use of advanced know-how methods, off-symmetry pieces were eliminated and costs cut for Pratt & Whitney.

Cooper Alloy, a specialist in stainless steel for 35 years, is still a pioneer in the development and application of new techniques for handling this tricky metal. Next time you have a tough casting problem, think of Cooper Alloy. *Send for your copy of our folder "Advanced Casting Know-How" today.*

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STRAITS TIN REPORT

MALAYAN TIN BUREAU

New developments in the production, marketing and uses of tin

Malaya's 780 active mines produced 62,295 long tons of tin-in-concentrates in 1956, the most since 1941. Output is continuing at a high level in 1957.

★ ★ ★

Straits tin is shipped from Malaya to the United States by three routes other than via Suez; so the closing of the canal has resulted in only slight delay in transit to Atlantic and Gulf ports, none to Pacific ports.

★ ★ ★

Straits, the world's best-known and most widely used grade of tin, is used in producing the tin plate for 9 out of every 10 tin cans made in the United States.

★ ★ ★

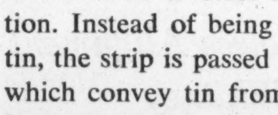
A new process for coating steel strip with tin was recently developed by the British Iron & Steel Research Association. Instead of being dipped in molten tin, the strip is passed between two rolls which convey tin from molten baths to both sides of the steel.

★ ★ ★

All of the millions of motor vehicles manufactured in the United States in 1956 contain tin—about 8000 long tons. New high-tin solders with unusually long life at temperatures as great as 223°F. have been developed for use in automobile radiators having operating pressures up to 16 psi.

★ ★ ★

A newly discovered alloy of zirconium, tin (4%) and molybdenum (1.6%) has four times the creep strength of pure zirconium at 930°F. This alloy can be readily rolled at 1470°F., and can be heat-treated to a strength of 140,000 psi.



Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses, and applications.

The Malayan Tin Bureau
Dept. 24C, 1028 Connecticut Ave., Washington 6, D.C.

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News OF INDUSTRY

Award, a plaque and cash honorarium of at least $500, is for: 1) technical achievement—significant scientific contributions of a metallurgical or engineering nature relating to the die casting process; 2) advancements in plant operations, management or administrative operational phases of the industry; 3) other activities resulting in the enhancement of the reputation and acceptability of die castings. In each class the achievement must be generally applicable to the industry.

Society of the Plastics Industry. Reinforced Plastics Div., has formed a new committee for development of faster, more accurate military specifications for reinforced plastics.

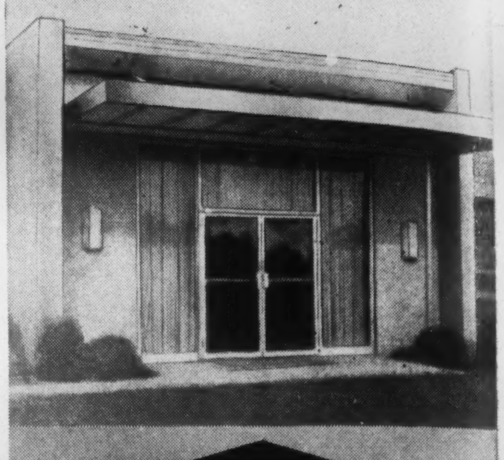
Institute of Environmental Engineers, a newly incorporated engineering society devoted to environmental science, simulation and testing, has announced the following officers: president, Charles E. Earl, Alpha Electric Refrig. Co.; executive vice president, E. S. Brown, Standard Cabinet Co.; executive committee: James Scibetta, Bowser Technical Refrigeration; Jack Shamroth, American Research Corp.; Saul Schiffman, Tenney Engineering, Inc. The institute publishes a quarterly magazine in conjunction with the Environmental Equipment Institute.

American Society for Metals, Penn State Chapter, will present its David Ford McFarland Award for Achievement in Metallurgy to Elwood D. Mairs, works manager, Alcoa extrusion and tubing plant at Penn State University on April 26.

Federation of Paint & Varnish Production Clubs has announced plans for the formation of a Paint Research Institute to conduct broad research and foster technical education for the benefit of the entire decorative and protective coatings industry. Members of the long range planning committee are: Newell P. Beckwith, Rinshed-Mason Co.; Hiram P. Ball, Ball Chemical Co.; Milton A. Glaser, Midland Industrial Finishes Co.; C. Homer Flynn, executive secretary of the Federation; Calvin J. Overmyer, Elliott Paint and Varnish Co.

(news of Meetings on p 268)

Paramount



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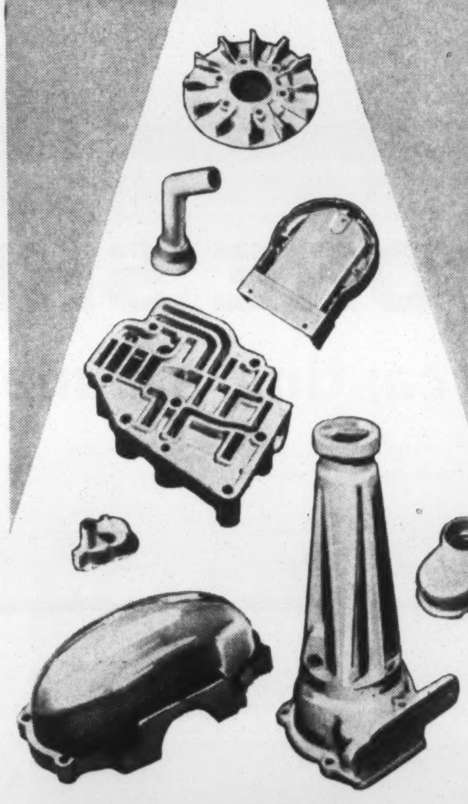

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Unretouched photomicrograph shows etched section of Type 304 stainless steel super-pressure tubing at a magnification of 50x. Note smooth, uniform ID and fine grain structure.

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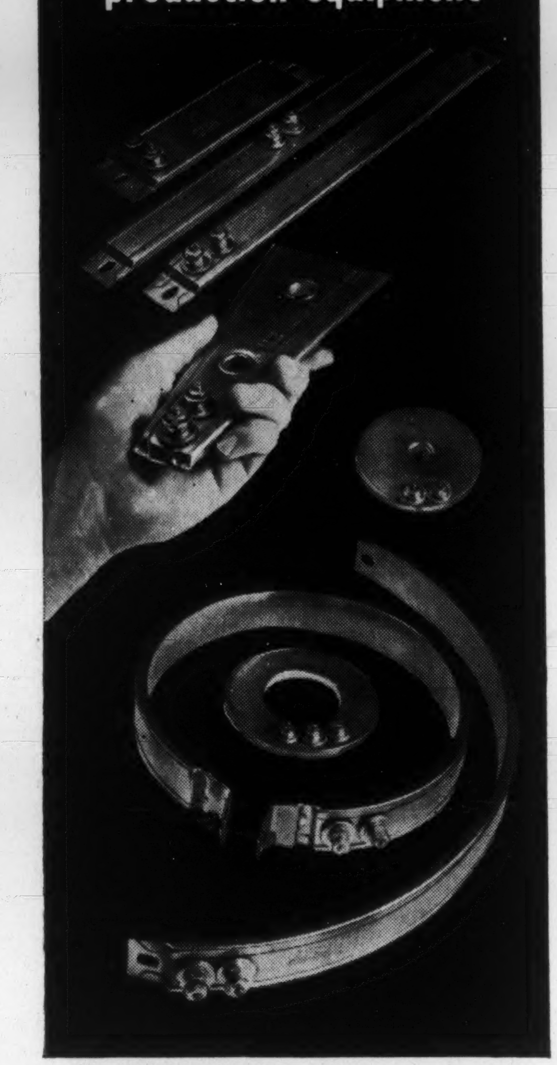

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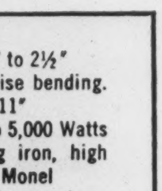

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News OF INDUSTRY

Meetings

AMERICAN SOCIETY OF TOOL ENGINEERS, technical meeting and convention. Houston. Mar 25-27.

AMERICAN SOCIETY FOR METALS. Western Metals Congress and Exposition. Los Angeles. Mar 25-29.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic production forum and aircraft engineering display. New York. Apr 2-5.

NATIONAL SCREW MACHINE PRODUCTS ASSN., annual meeting. Washington, D. C. Apr 7-10.

AMERICAN WELDING SOCIETY, national spring technical meeting and annual convention. Philadelphia. Apr 8-12.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, spring meeting. Birmingham, Ala. Apr 8-10.

MALLEABLE FOUNDERS' SOCIETY, market development conference. Chicago. Apr 10-11.

NATIONAL NUCLEAR INSTRUMENTATION CONFERENCE, third Southeastern exhibit. Atlanta, Ga. Apr 10-12.

PACIFIC NORTHWEST REGIONAL CONFERENCE. Portland, Ore. Apr 11-13.

AMERICAN INSTITUTE OF MINING, METALLURGICAL & PETROLEUM ENGINEERS. Conference on high temperature materials. Cleveland. Apr 16-17.

INSTITUTE OF RADIO ENGINEERS, Southwestern conference and electronics show. Houston. Apr 11-13.

AMERICAN FOUNDRYMEN'S SOCIETY, East Coast regional conference. Philadelphia. Apr 12-13.

UNITED STATES WORLD TRADE FAIR. New York. Apr 14-27.

AMERICAN SOCIETY FOR TESTING MATERIALS, nuclear energy symposium. Chicago. Apr 16-18.

AMERICAN ZINC INSTITUTE, annual meeting. Chicago. Apr 24-26.

INSTITUTE OF ENVIRONMENTAL ENGINEERS, annual technical meeting. Chicago. Apr 25-26.

METAL POWDER ASSN., annual meeting and metal powder show. Chicago. Apr 30, May 1.

AMERICAN FOUNDRYMEN'S SOCIETY, annual convention. Cincinnati. May 6-10.

COPPER & BRASS RESEARCH ASSN., annual meeting. Hot Springs, Va. May 12-15.

ELECTROCHEMICAL SOCIETY, INC., spring meeting. Washington, D. C. May 12-16.

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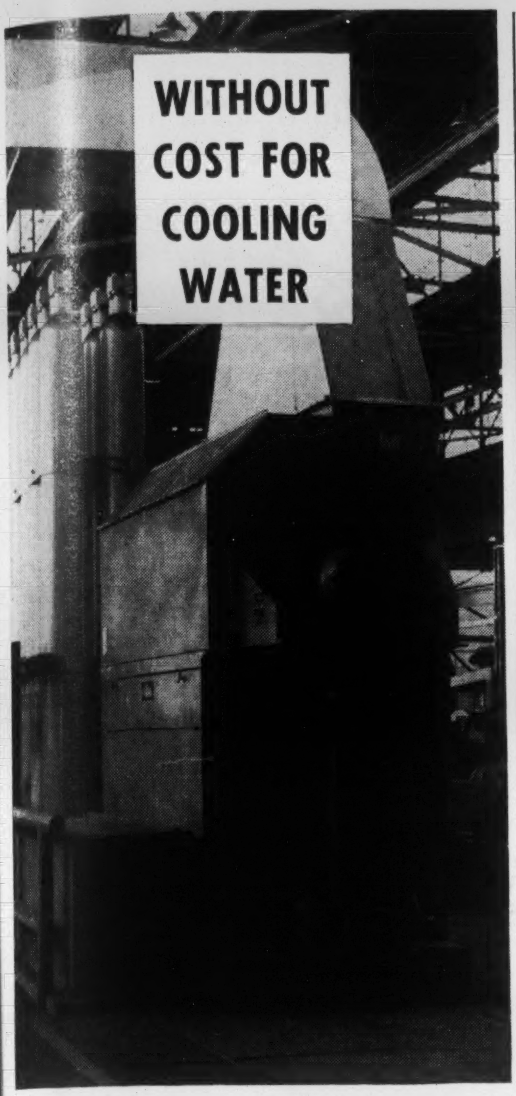

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BOOKS & REPORTS

Books

Elements of Engineering Materials. *C. P. Bacha, J. L. Schwalje and A. J. Del Mastro. Harper & Bros., New York 16, N. Y. 1957. Cloth, 6¼ by 9½ in., 494 pp. Price $6.50.*

This book discusses the elements and applications of engineering materials and gives the latest practices available in each field. Only elementary information is given since the book is intended as an introductory text on engineering materials. However, lists of suggested references for further study have been included in order to supplement the information given in each chapter.

The book is broken down into four parts: 1) fundamental engineering materials, 2) ferrous and nonferrous materials, 3) protective coatings, and 4) nonmetallic materials.

Symposium on Metallic Materials for Service at Temperatures Above 1600 F. *American Society for Testing Materials, Philadelphia. 1956. Paper, 6 by 9 in., 200 pp. Price $3.50.*

The papers given in this symposium attempt to evaluate a number of metallic materials, including nickel, cobalt and molybdenum-base alloys, to determine their suitability for high temperature service. Some of the papers discuss the physical, chemical and mechanical properties of these materials and give methods of combating surface deterioration. Other papers seek to solve high temperature problems through the use of carbides, powder metallurgy techniques and ceramic coatings.

Engineering Inspection, Measurement and Testing. *H. C. Town and R. Colebourne. Philosophical Library, New York. 1956. Cloth, 6 by 9 in., 192 pp. Price $8.75.*

Illustrated with numerous diagrams and photographs, this book gives a brief history of length standards in this country and explains the function of the inspection department in the modern factory. The

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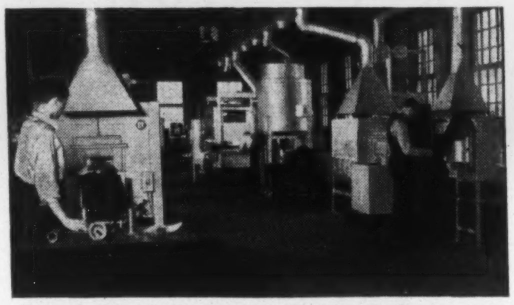

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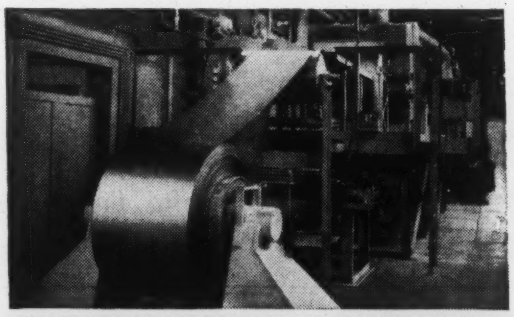

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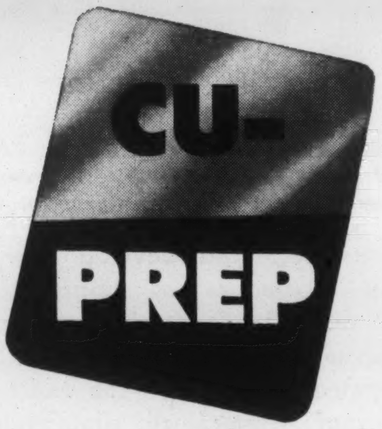

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book also deals with the use of comparators and other measuring and inspecting machines and discusses such topics as: measurement of surface finishes, screw thread measurement, and measurement during machining and sizing.

Vacuum Deposition of Thin Films. *L. Holland. John Wiley & Sons, New York. 1956. Cloth, 6 by 9 in., 465 pp. Price $10.*

Although this book is concerned primarily with plant design and operation for producing vacuum deposited thin films, attention is given to the structure, physical properties and applications of these films.

Materials and Processes in Manufacturing. *By E. Paul Degarmo. Macmillan Co., New York 11, N. Y. 1957. Cloth, 6¼ by 9½ in., 755 pp. Price $8.50.*

The subject matter in this book is concerned with materials in manufacturing procedures. It explains how and why a given material is used for a certain manufacturing application and why it reacts as it does when processed.

The book, intended as a college level text for engineering students, is divided into five parts and covers: 1) alloy steels and irons, nonferrous alloys and plastics, 2) powder metallurgy and hot and cold working processes, 3) milling, boring, sawing and grinding, 4) forge, gas, arc and resistance welding, and brazing and soldering, and 5) other processes and techniques related to manufacturing, such as layout, jigs, fixtures and tools.

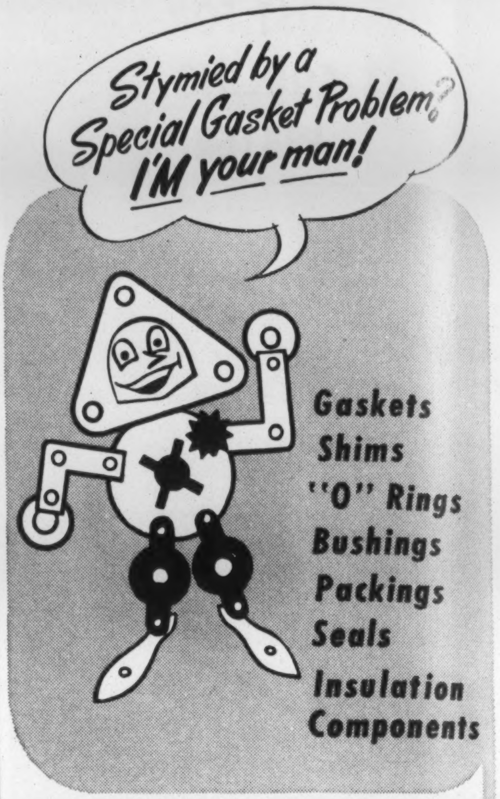
Reports

Zirconium alloys DEVELOPMENT OF ZIRCONIUM ALLOYS. PART II. *A. D. Schwope, L. L. Marsh and W. Chubb, Battelle Memorial Institute. Nov 1955. 25 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 25 cents (BMI-79)*

Small additions of molybdenum, tantalum, tin, titanium and nitrogen increase the high temperature tensile strength of zirconium.

Thermal shock resistance THERMAL SHOCK INVESTIGATION. *T. A. Hunter, L. L. Thomas and A. R. Bobrowsky, University of Michigan. Sept 1954. 106 pp. Available from Office of Technical Services, Dept. of*

Mr. Auburn says: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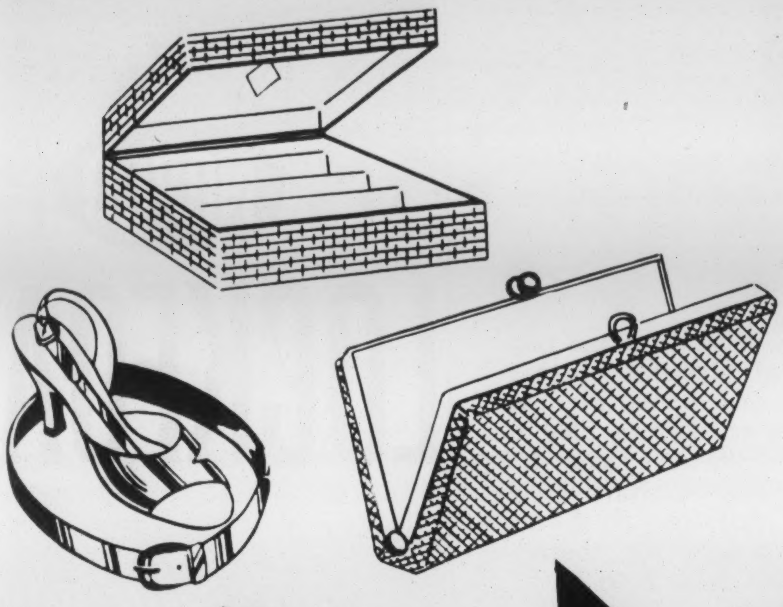

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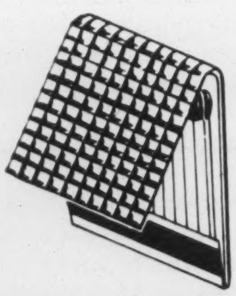

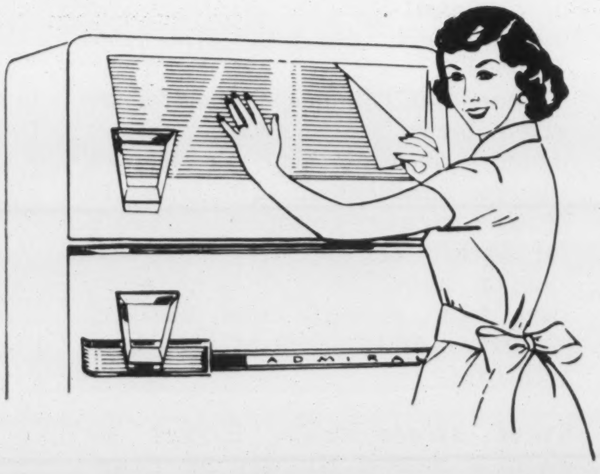

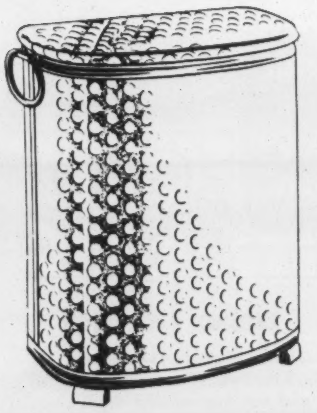

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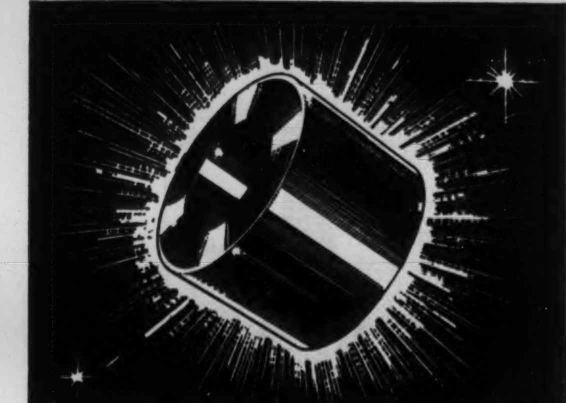

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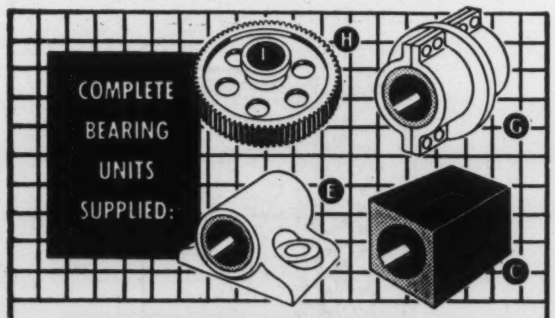

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Aluminum-iron alloys THE FABRICATION AND PROPERTIES OF ALFENOL ALLOYS (AL-FE) CONTAINING 10 TO 17% ALUMINUM. *J. F. Nachman and W. J. Buehler, Naval Ordnance Lab. Dec 1955. 26 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. 75¢ (PB 111552S)*

Magnetic data are given for laminated cores of Alfenol varying in aluminum content from 10 to 17%. The report describes improved methods of fabrication by melting and casting to obtain a fine equiaxed cast grain structure. The study indicates that these alloys are potential substitutes for many current magnetic alloys containing strategic elements.

Titanium properties TENSILE AND IMPACT PROPERTIES OF COMMERCIAL TITANIUM OVER THE TEMPERATURE RANGE OF 385 TO 930 F. *L. Sama, A. J. Opinsky and L. L. Seigle, Sylvania Electric Products, Inc. Sept 1954. 45 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.25 (PB 121086)*

Tensile and impact properties are given for a titanium alloy tested under three conditions: as received, vacuum annealed at 1560 F for 24 hr, and vacuum annealed at 1740 F for 24 hr. Tensile tests show that vacuum annealing and large grain size lower strength and ductility properties of titanium at high temperatures.

Steel stress-strain EFFECT OF FATIGUE STRESS HISTORY ON ELASTICITY PROPERTIES AND STRESS DISTRIBUTION UNDER ROTATING BENDING. *L. C. Lidstrom and B. J. Lazan, Univ. of Minnesota. Aug 1956. 55 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.50 (PB 121523)*

A method used for calculating specific stress-strain relationships of mild steel is described. Data show the effect of fatigue stress amplitude on the stress-strain properties of mild steel under axial stress. Fatigue

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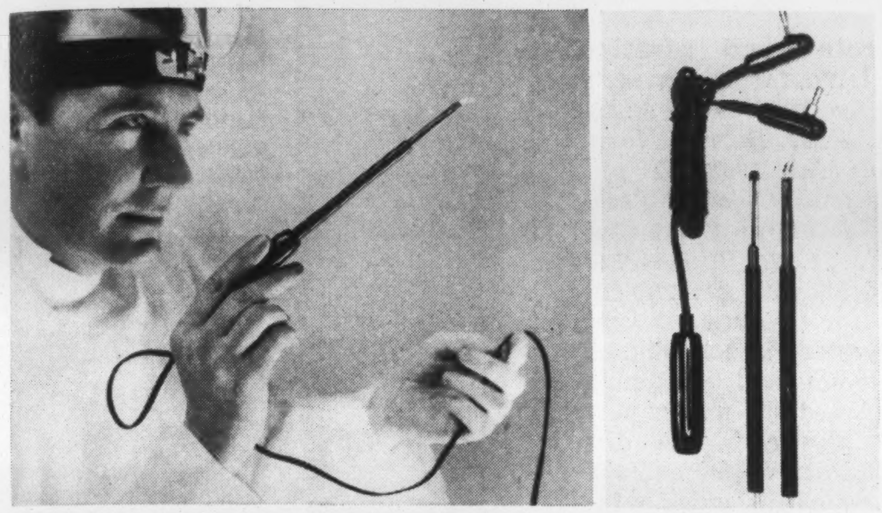

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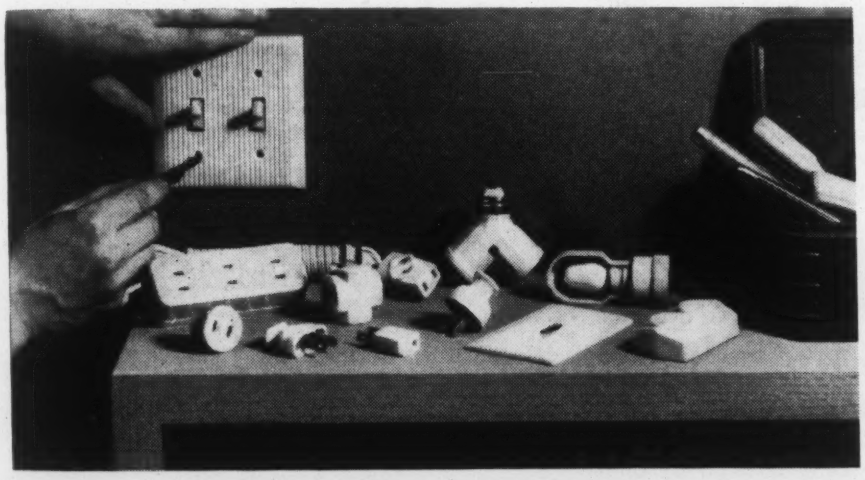

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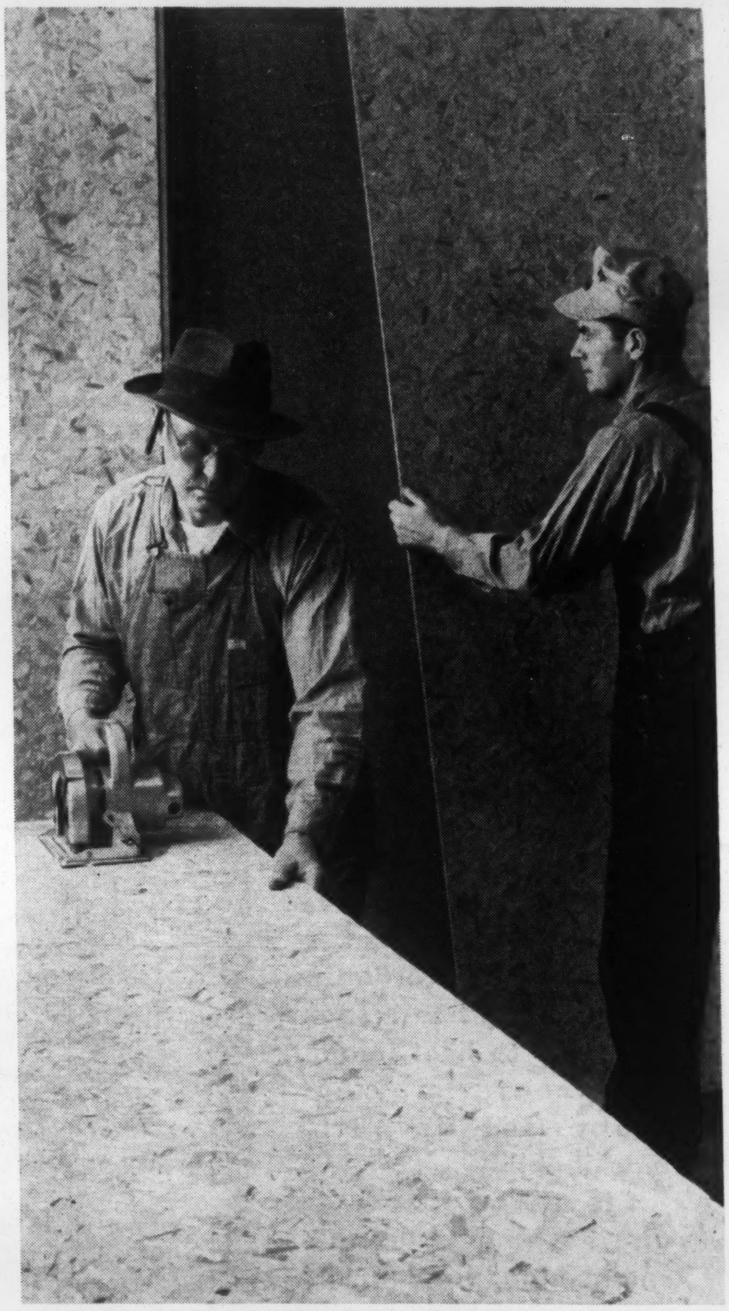

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data on solid and hollow rotating beams under axial stress show poor agreement when compared on the basis of nominal stress; when compared on the basis of specific or true stress, agreement is good.

Specifying reinforced plastics Defects of Importance in the Specification of Reinforced Plastics Products. *F. R. Barnet, Naval Ordnance Lab. Mar 1953. 54 pp., illus. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.50 (PB 121277)*

This report deals with government specifications for polyester type resins and polyester-glass laminated plastics. Minimum and maximum properties are listed for use in purchasing these plastics. Also discusses visual characteristics and the various flaws found in glass reinforced plastics. Appendices list types of defects and allowable flaws found under typical service conditions.

Welding cast iron Tentative Specification for Welding Rods and Covered Electrodes for Welding Cast Iron. *Available from American Welding Society, 33 W. 39th St., New York 18, N. Y. 40¢ (AWS Designation: A 5.15-56T)*

Tentative specifications cover filler metals for welding cast iron, malleable iron and some alloy cast irons. Sixteen classifications of filler metal are covered, including cast iron, copper-base, nickel-base and mild steel electrodes for shielded metal arc welding. An appendix is included.

Transistors Research and Development Study of Gold Bonded Transistors. *P. Toong and R. Yee, Transistor Products, Inc. Aug 1954. 44 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1 (PB 111669)*

Transistors were produced by electrically bonding gallium-doped gold wire to a thin germanium crystal. The transistors showed promise for numerous amplifying and switching applications.

Rot resistant fabrics Evaluation of Rot Resistant Treatments for Elastomer-Coated Fabrics. *J. M. Ashcroft, U.S. Army Corps of Engineers. July 1955. 51 pp., illus. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C. $1.25 (PB 121420)*

Evaluates commercially available rot resistant treatments applied to cotton fabrics coated with elastomers.

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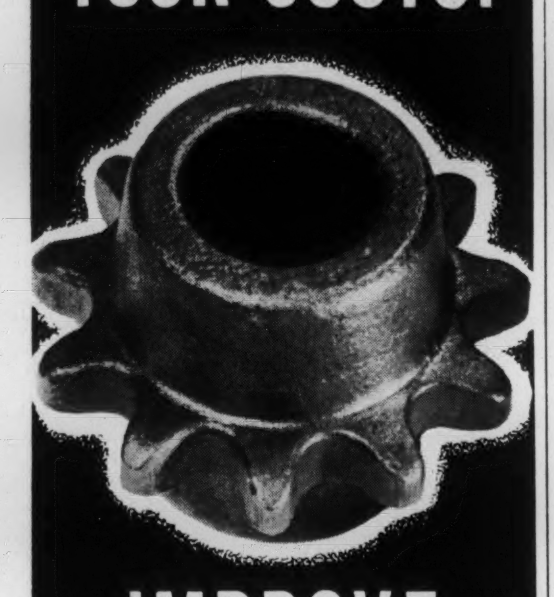

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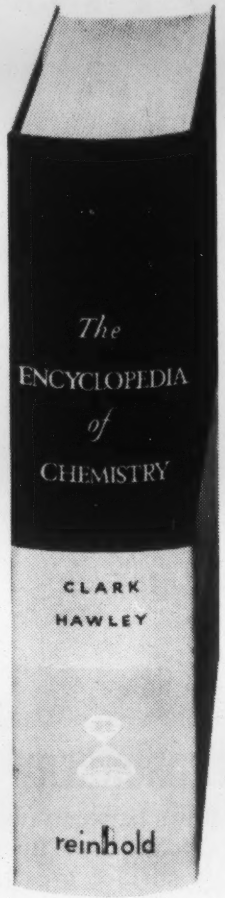

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THE LAST WORD

by **H. R. Clauser**, *Editor*

What's in the Name

For a long time we have questioned the wisdom of referring to MATERIALS & METHODS as M&M. Well, we now have the answer. In a recent survey, 160 people were asked what they thought of first when they saw the letters M&M. Much to our disappointment, about 60 of them were reminded of M&M candies and only 21 thought of us. Two fellows immediately thought of Marilyn Monroe. Another fellow thought of Mounds (i.e. when he saw M&M).

We Told You So

In January we published an editorial ("One Point of View") which among other things took issue with the prevailing and popular view that the number of students studying engineering was dangerously low and that prospects for the future were not bright. We now have some figures on 1956 college enrollments that support our stand. The *College and University Bulletin* reports that the number of students enrolled in engineering courses increased about 14% over 1955 against an increase of only 8% for all college courses.

No Brickbats Yet

It was with some trepidation that we began in January to publish a page that for the first time anywhere lists current price levels of all important engineering materials (in this issue, page 228). Many of the people we consulted said it couldn't be done. Others warned us that both producers and users of materials would jump on us for any one of a number of reasons. But so far there have been no serious complaints.

The apparent success of this attempt to give engineers some idea of the current prices of all the materials they have to use is in large measure due to the extensive help we have received from a great many organizations. We appreciate all the help and we know that the many engineers and designers who have been asking for such information will appreciate it too.

In this issue we are adding what we think is another first to the prices page. We are listing the current cost of organic coatings, and the figures are given not in cost per gallon, as is usually done, but in a more useful form—cost per square foot per mil of dry film thickness. There will be other additions as well as refinements to this new materials price department in the months ahead. If you have any suggestions for improvement please let us know about them.

You Too Can Be a Mad Bomber

There is no telling what the do-it-yourself fad will lead to next. Just the other day I learned from the Association of Casualty & Surety Companies that there is such a thing as a do-it-yourself explosive. According to them, it is a relatively simple matter to mix carbon black and fertilizer-grade ammonium nitrate and get an effective and low cost explosive. Apparently an increasing number of people are mixing their own explosives in just this way, and are using them in place of such conventional explosives as dynamite or black powder for blasting.

How to Get a Seat in the Subway

Come to think of it, the "mad bomber" of New York was a do-it-yourselfer. He made pipe bombs in his garage. In a way I was almost sorry to see them catch him, because as long as he was at large, I had no trouble getting a seat on the subway. But now when I force my way into a crowded subway car, the people no longer scatter at the sight of the brown paper package tucked under my arm.